PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 7 :
A01J 5/013, A01K 29/00, G01N 33/06, 21/85, G01J 3/42, G01N 21/53

A1

(11) International Publication Number: **WO 00/64242**

(43) International Publication Date: 2 November 2000 (02.11.00)

(21) International Application Number: PCT/NL00/00273

(22) International Filing Date: 27 April 2000 (27.04.00)

(30) Priority Data:
1011905 27 April 1999 (27.04.99) NL
1013805 9 December 1999 (09.12.99) NL

(71) Applicant *(for all designated States except US)*: COÖPERATIE RUNDVEEVERBETERING DELTA U.A. [NL/NL]; Wassenaarweg 20, NL–6843 NW Arnhem (NL).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: DOMMERHOLT, Johannes [NL/NL]; K. Doormanlaan 17, NL–3941 WL Doorn (NL). WILMINK, Johannes, Bernardus, Maria [NL/NL]; Harnsesteeg 3, NL–6721 NH Bennekom (NL). BORSBOOM, Petrus, Cornelus, Franciscus [NL/NL]; Oude Boor 6, NL–9922 PL Westeremden (NL).

(74) Agent: GROOTSCHOLTEN, Johannes, Antonius, Maria; Arnold & Siedsma, Sweelinckplein 1, NL–2517 GK The Hague (NL).

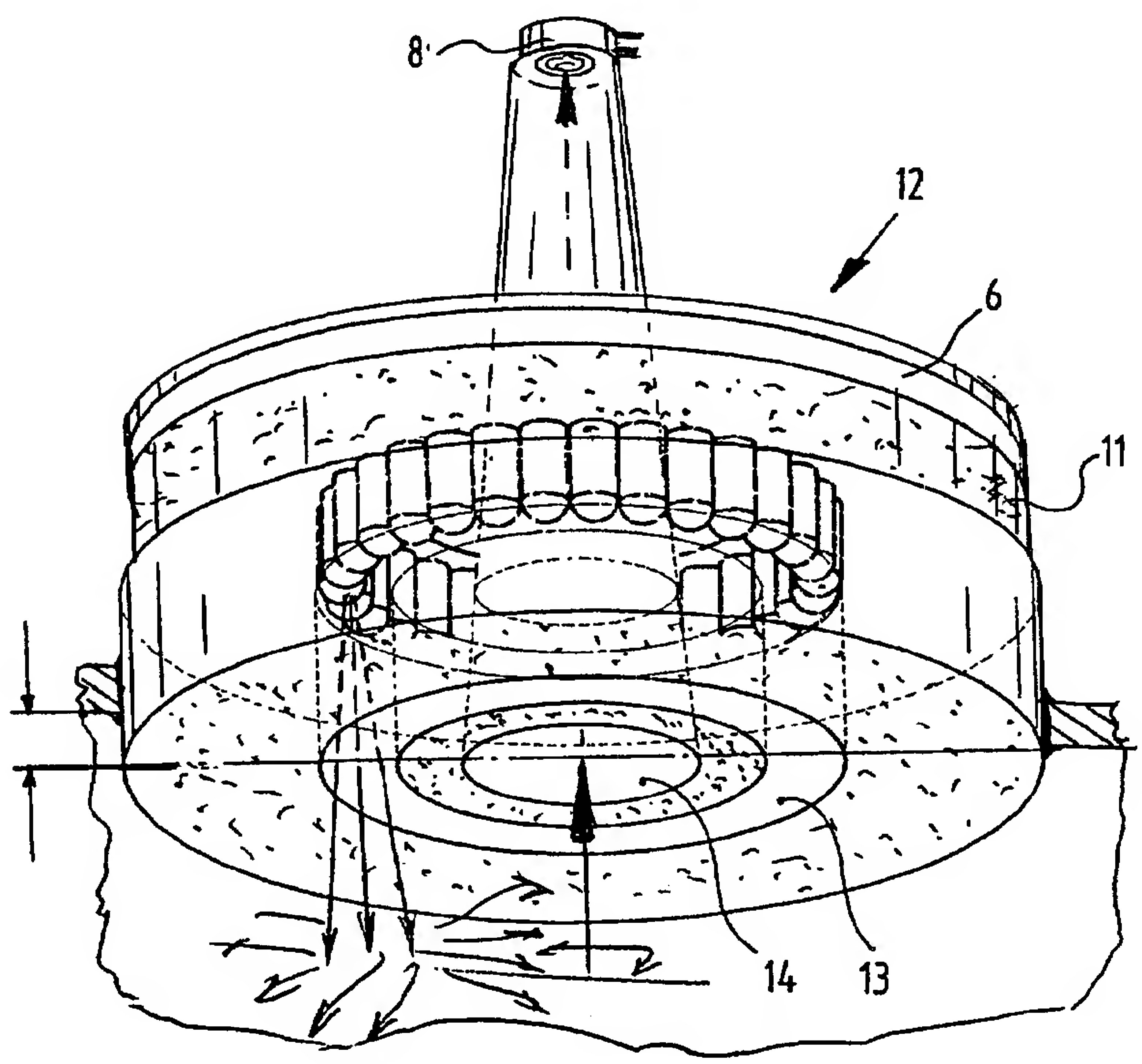
(81) Designated States: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published
With international search report.
In English translation (filed in Dutch).

(54) Title: MEASURING HEAD FOR A DEVICE FOR ANALYSING PRODUCTS

(57) Abstract

The application concerns a measuring head for an analysing device which includes: a spectrophotometer which has a source for electromagnetic radiation with at least one spectral component chosen from the wavelength region between 300–2500 nm; a photo sensor which is sensitive for at least the first, second and third and possibly the fourth harmonic or spectral components, which belong to the used wavelength region, especially between 300–2500 nm, the photo sensor being arranged with respect to the product to be analysed in such a way that the sensor receives radiation scattered by the product through transmission, reflection and/or volume reflection; and a signal analysing unit which is connected to the sensor; and a volume, designed to contain the products to be analysed, in which the working areas of both the source and the sensor are exposed.



FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	**ES**	Spain	**LS**	Lesotho	**SI**	Slovenia
AM	Armenia	**FI**	Finland	**LT**	Lithuania	**SK**	Slovakia
AT	Austria	**FR**	France	**LU**	Luxembourg	**SN**	Senegal
AU	Australia	**GA**	Gabon	**LV**	Latvia	**SZ**	Swaziland
AZ	Azerbaijan	**GB**	United Kingdom	**MC**	Monaco	**TD**	Chad
BA	Bosnia and Herzegovina	**GE**	Georgia	**MD**	Republic of Moldova	**TG**	Togo
BB	Barbados	**GH**	Ghana	**MG**	Madagascar	**TJ**	Tajikistan
BE	Belgium	**GN**	Guinea	**MK**	The former Yugoslav Republic of Macedonia	**TM**	Turkmenistan
BF	Burkina Faso	**GR**	Greece			**TR**	Turkey
BG	Bulgaria	**HU**	Hungary	**ML**	Mali	**TT**	Trinidad and Tobago
BJ	Benin	**IE**	Ireland	**MN**	Mongolia	**UA**	Ukraine
BR	Brazil	**IL**	Israel	**MR**	Mauritania	**UG**	Uganda
BY	Belarus	**IS**	Iceland	**MW**	Malawi	**US**	United States of America
CA	Canada	**IT**	Italy	**MX**	Mexico	**UZ**	Uzbekistan
CF	Central African Republic	**JP**	Japan	**NE**	Niger	**VN**	Viet Nam
CG	Congo	**KE**	Kenya	**NL**	Netherlands	**YU**	Yugoslavia
CH	Switzerland	**KG**	Kyrgyzstan	**NO**	Norway	**ZW**	Zimbabwe
CI	Côte d'Ivoire	**KP**	Democratic People's Republic of Korea	**NZ**	New Zealand		
CM	Cameroon			**PL**	Poland		
CN	China	**KR**	Republic of Korea	**PT**	Portugal		
CU	Cuba	**KZ**	Kazakstan	**RO**	Romania		
CZ	Czech Republic	**LC**	Saint Lucia	**RU**	Russian Federation		
DE	Germany	**LI**	Liechtenstein	**SD**	Sudan		
DK	Denmark	**LK**	Sri Lanka	**SE**	Sweden		
EE	Estonia	**LR**	Liberia	**SG**	Singapore		

MEASURING HEAD FOR A DEVICE FOR ANALYSING PRODUCTS

The invention lies in the field of measuring heads for analysis of products, for instance raw milk, faeces, manure, soil, urine, fruit (slices), potatoes, (slabs of) tooth material etc., hereinafter regularly referred to for the sake of brevity as "products".

It is an object of the invention to provide a device which enables a rapid, accurate, non-destructive analysis of the structure and composition of products with a relatively simple, inexpensive measuring head which is cheap to produce.

It is also an object of the invention to provide a measuring head for an analysis device with which for instance samples of basic products, such as raw milk, can first be measured, whereafter a measurement takes place of processed products, for instance homogenized or fermented milk, such that effects of the processing in question can be determined on the basis of parameter values to be specified below.

It is a further object of the invention to embody a measuring head for an analysis device such that it is inexpensive, not very vulnerable and lends itself to being optionally incorporated with few modifications in an installation, for instance a milking robot or an automatic milking plant comprising a plurality of robots, a fruit or vegetable processing installation and so on.

On the basis of such a device insight can be acquired in simple manner into data essential for operational management. This point will be further discussed below. Of importance is the possibility of gathering data and monitoring processes associated with treatments of (basic) products. Monitoring can be defined as following variations and trends. In this

respect the required measurement accuracy per measurement is determined more by variations in the product and the process than by measurement results relative to a standard definition, for instance a wet chemical determination (IDF or other ISO standards).

With a view to the above stated objectives, the invention provides a measuring head for a device for direct analysis of products, such as milk given by lactating animals, for instance raw milk, processed milk such as fermented milk, yoghurt and the like, faeces, manure, urine, fruit slices, potatoes, slabs of tooth material etc., such that the value of at least one parameter is measured or detected, for instance the total quantity of milk from one milking session, the milk flow rate during milking, the structure, the fat content, the fatty acid composition, the protein content, the protein composition, the number of somatic cells optionally specified per type, urea content, ketone body content, determining of ketone body details, hormone levels, lactose content, blood content, beestings characteristics, which device comprises:

a spectrophotometer with:

a source of electromagnetic radiation with at least one chosen spectral component in the wavelength range of about 300-2500 nm;

a photosensor which is sensitive to at least the first, second and third, and optionally the fourth harmonics or spectral components associated with the wavelengths used, in particular about 300-2500 nm, and which in relation to the products for analysis is disposed relative to the source such that the sensor receives radiation scattered via the product for analysis by transmission, reflection and/or volume reflection; and

a signal processing unit which is connected to the sensor and which can generate signals representative

of the spectral composition of the radiation sensed by the sensor; and

a space which is adapted to contain products for analysis, into which space both the source and the sensor debouch with their active surfaces, to which space connect feed and outfeed means for feed and outfeed of milk, which means are adapted to be connected to respectively a supply and discharge of products for analysis, wherein the measuring head comprises the source or the sensor, wherein a light-conducting assembly and a carrier for the source or the sensor are mutually connected to form a unit with the source or the sensor therebetween.

It is noted that the present invention also relates to a method for manufacturing a measuring head in accordance with a system as described above.

With a separate light-conducting assembly, such as is used for connection to the carrier for the source or the sensor, it is possible to test the light-conducting assembly in advance, prior to assembly with the carrier, for the desired light transmission characteristics. This results in an optimization of the optical path for each of the measuring heads produced in this manner. The carrier with the source or the sensor thereon can also be separately tested before being connected to the light-conducting assembly. Such a connection can be effected by integral moulding of both elements. The source will usually comprise a number of elements, for instance a lens, each having its own frequency characteristic. The assembly of sources on the carrier can thus be tested, if required even in combination with a local variation in the transmission characteristics of the light-conducting assembly as a function of the different frequency characteristics of the source elements.

Different embodiments are possible and advantageous, as will be further described hereinbelow.

By dividing production of the measuring head into a light-conducting assembly and a carrier for sources or sensors a simplification of the production process is achieved, more reliable measuring heads can be provided, which measuring heads can also be simpler and easier to produce, and so on.

Calibration of the indirect measurement by means of the device according to the invention can take place via a chemical and/or physical analysis of a series of samples.

In order to monitor the operation of the analysis device according to the invention a distinction can be made in respect of testing inter alia the following relevant properties: sensitivity, dark current noise, contamination, temperature characteristics, wear, ageing. Such functions are tested using so-called calibration standards, usually comprising a diffuse white or a black reflector or neutral grey filters which is or are placed at a distance from or in a measuring head. Depending on the stability and the established characteristics of the device the monitoring measurement is carried out daily, weekly or monthly. Alternatively, the application of a white or fluorescent reference liquid can be envisaged. It is also conceivable that when an installation with an analysis device according to the invention is cleaned a liquid is used which has a partial calibration function, or to embody the device such that in the absence of products for analysis a reflective surface is always detected by the measuring head. Such a surface can be deemed a derived calibration standard.

Testing can also be carried out for noise characteristics and signal transfer. Testing for these properties is performed in combination with the above mentioned calibration routine.

The above overview relates to all monitoring of functions of the physical system.

Another component of the calibration relates to the deriving of spectral information, on which the device according to the invention is after all based, as to the composition of the product for analysis. Diverse "conversion methods" are available for this purpose. All calculations are however based on, and therefore dependent on, so-called wet chemical analysis or physical analysis of the composition. The problems here are sensitivity, reproducibility, error margins of the reagents used and reactions, and so on.

Standard software can be used for derivation, for instance Unscramble from the company Camo, or similar calculations based on multivariation analysis, or applying neural networks.

The applied spectroscopic analysis in the range 300-2500 nm is based on typical, and partly overlapping optical absorption bands of C-H, O-H or N-H bonds of chemical type. Spectroscopy in the range 300-2500 nm has the advantage compared to other per se known measuring methods such as FTIR, Raman and NMR of a low production and purchase price and simple operation. The NIR spectral range, which lies roughly in the order of 700-2500 nm, comprises the range within which the harmonics of molecule vibrations are relevant. The first resonance frequency or second harmonic relates for instance to the range of 1400-1800 nm; the third harmonic to about 950-1200 nm and the fourth harmonic to 700-925 nm. Reference is made in this respect to Practical NIR Spectroscopy with Applications in Food and Beverage Analysis by B.G. Osborne et al. ISBN 0-582-09946. It has been found from measurements that not only is the NIR range 700-2500 nm of interest, but that relevant information can also be obtained from the range 300-700 nm.

Essential in the use of ultra-violet radiation, visible light and near infrared radiation are the optical characteristics of the object for measuring, particularly the wavelength-dependent absorption and

scattering coefficients. These properties determine to a considerable extent the conditions for an optimal measurement geometry and the associated sensitivity, accuracy and reproducibility of the measuring method.

It has been found from absorption measurements on water that the absorption coefficient increases sharply as a function of the wavelength. This relates to the absorption of H_2O (O-H band). The fourth harmonic lies in the order of 745 nm, third harmonic in the order of 975 nm and the second harmonic at about 1485 nm and the first harmonic at 1940 nm. Similar characteristics of C-H and N-H bonds (increase in the absorption coefficient at greater wavelengths) are known. At wavelengths above 2000 nm the absorption of H_2O is so high that NIR measurements in aqueous suspensions or in solutions are difficult to use because with a large optical path the signal/noise ratio becomes very unfavourable due to the high absorption, particularly of H_2O.

The scattering characteristics (i.e. the usually anisotropic change of light direction through the internal structure of the product for analysis) are determined inter alia by the form of the particles, particle sizes, the distribution of the particle sizes, the distribution of the particles, variation of the refractive index (wavelength-dependent functions). Particularly in materials of biological origin the scattering characteristics can often be directly derived as to the structure of specific components. Material with scattering cores with dimensions smaller than the wavelengths used display scattering characteristics differing from scattering cores larger than the wavelengths used. The characteristics are considerably more complex in the case of a combination of multiple types of scattering cores, such as is the case with milk (dimensions micelles about 80 nm, fat particles on average about 1000 nm and somatic cells around 15 μm) and many other materials, whether or not they are

biological. The scattering coefficient generally decreases in the visual and the NIR range as wavelength increases. The decrease in the scattering coefficient and the increase in the absorption coefficient in the range 300-2500 nm results in a practically applicable window for measuring techniques based on transmission and/or volume reflection with a relatively long optical path. As a result of the anisotropic scattering characteristics dependent on wavelength and particle size the measuring result in the case of transmission will depend mainly on the forward scatter effect. In (volume) reflection the measuring result will depend mainly on backward scattering effects. The choice for transmission measurement or volume reflection measurement, or a combined transmission and volume reflection measurement in one measuring device is also determined by a desired sensitivity for particular particle structures. Form and position of the window in the relevant spectral range depend on the optical properties of the object for measuring.

The ideal measurement geometry depends not only on the optical properties of the object but also on practical conditions, such as (potential and possibly progressive) contamination of measuring window, foam formation, flow, separation and so on. It is found in practice that measurement in the largest possible measurement volume is desirable in respect of possible intra-variation in the object and a smaller influence of possibly contaminating or contaminated measuring windows. A long optical path through the object for measuring provides more reliable information than a short optical path. The maximal optical path is however limited by the minimum permissible signal/noise ratio. By intermittent driving or chopping of the light source and synchronous detection (lock-in amplifier) the noise can be suppressed and the sensitivity improved. For milk and other light-scattering materials into which the

light can penetrate deeply over a distance of many millimetres, a volume reflection measurement (measurement wherein in the measuring surface there is some distance between the source surface and the sensor surface and the radiation is thus forced to cover a certain distance in the milk, also referred to as forced minimal optical path) is strongly recommended over a reflection measurement (wherein depending on the scattering characteristics of the light-scattering materials the optical path can be very short). In volume reflection (wherein the adverse effects of surface reflection are precluded) the back-scattering characteristics resulting from the internal material structure are applied and optical path lengths of 10 mm and more can be realized. An objective measure for a correct measuring device and wavelength range relating to a specific object for measuring is the contrast for the wavelength-dependent absorption and scattering characteristics in an obtained spectrum. Various aspects can be tested with a model to be manufactured from suspensions on a basis of commercially obtainable latex particles of different relevant dimensions and the addition of different commercially obtainable absorbers.

For transmission and volume reflection measurements use can be made in the wavelength range of about 300-2000 nm of relatively inexpensive, commercially obtainable detectors, at this moment for instance InGaAs, Si and Ge detectors or combinations thereof. CCDs, normal or Si light conductors, a standard monochromator, a halogen or xenon light source or at least one LED, LED-laser, polymer LED and polymer laser or the like. An LED or a polymer LED can optionally be provided with a transmission interference filter to reduce the band width of the emitted electromagnetic radiation from for instance 50-100 nm to about 10-20 nm. The wavelength range can be subdivided into a number of bands. For the relevant range use can for instance be

made according to the invention of a subdivision into ten to twenty spectral bands. If it is desired to perform a larger or smaller number of parameter value measurements, this number can optionally be further increased or decreased. In the case of in-line milk analysis very good results have been achieved with a test arrangement. The wavelengths of not only the detector(s) but also of the light source or light sources can be selected such that the spectral analysis according to the invention can produce measurement results which correspond with the values of desired parameters as stated above, for instance fat content, fatty acid composition, protein content and so on. It has been found that wavelength-dependent measurements can show which wavelengths produce the best analysis results for the different parameters and parameter groups to be tested. These wavelengths can also be implemented in an embodiment of the device according to the invention wherein LEDs are applied as radiation sources, and a plurality of sources can be applied which are each tuned to a spectral range associated with one parameter.

The device according to the invention could prove useful on the basis of, among others, the following considerations which relate to direct control in the short term, these considerations relating to the field of application of this invention stated as example, i.e. dairy farming:

- lower cost-price for milk-monitoring in operational management

- control of milk quality of groups and individual lactating animals

- sending of the milk to diverse destinations on the basis of milk quality and milk composition

- qualitative and quantitative monitoring of the functioning of the milking installation

- insight into the state of health of the lactating animals, in particular cows; possibility of analysing individual health problems such as mastitis

- insight into the progress of the milking session and the milk composition resulting from natural phases during lactation; colostrum, oestrus, undernourishment, other functions

- insight into the response of lactating animals to feed and living conditions.

Referring again to the above example, dairy farming, the suppliers and customers of farmers benefit from the use, particularly on large scale, of the devices according to the invention. A number of considerations relating to longer-term indirect control are the following:

- Producers and suppliers of milking installations obtain an extra added value for their product with the inclusion of a device according to the invention, as well as a better insight into their installations

- Suppliers of animal feed can obtain a good insight, particularly in the longer term, into the effects of possible changes in the feed components

- The device according to the invention is important for a dairy plant since during the qualitative separation of milk at the farm a distinction can already be made between various raw main component categories, whereby an extra added value and possibly lower processing cost-price can be realized

- Accurate insight into the quantity and composition of the milk supplied by a dairy farmer

- Relevant information for companies involved in genetic techniques

- The devices according to the invention, particularly when used on large-scale, are also important for suppliers of data transmission systems and providers of telecommunications facilities. Central use of information or data-mining is also possible. In this way a statistical analysis of measurement data can for instance take place, deeper analysis of the data can take place to obtain information about individual lactating animals and, for instance on the basis of an interactive system, report-back to the dairy farm can be realized

- Through the continuous monitoring of the quality of the milk the average quality of milk to be purchased by the consumer can already increase substantially during the milking session using simple provisions and at relatively low cost, and can thereby comply more readily with quality standards, for

instance ISO, GMP, GLP/KKM (translated as: chain quality milk) and/or HACCP standards.

In respect of the accuracy to be realized and the associated prerequisite of a certain resolution of the device, with the volume reflection measuring device to be described hereinbelow, making use of the wavelength range 500-1100 nm and with an average sample of product for analysis such as untreated raw milk, the following accuracies relative to the measured values can now already be realized at each individual measurement for the parameters stated below:

fat	:	ca. 5 %
protein	:	ca. 3 %
lactose	:	ca. 2.5 %
cell number 0-150,000	:	ca. 10 %
cell number 150,000-1,000,000	:	ca. 30 %
blood	:	detection for presence suffices
beesting characteristics	:	detection for characteristics suffices

The total accuracy to be realized per parameter corresponds with the given relative accuracy for each individual measurement as according to the above table divided by the root of the number of measurements. It will be apparent that with an increase in the number of measurements the effective measurement accuracy can be substantially improved.

It is anticipated that in a relatively large-scale study over a longer period of time, for instance within the context of the field of application mentioned as example, dairy farming, a minimum of 1,000,000 measurements, 1,000 cows, 10 farms with identical measuring systems, more extensive and better calibration information can be obtained relating to inter alia diverse types of milk abnormalities, general health of the lactating animals, feed conversion, oestrus, genetic properties and so on.

The invention provides the option in the field of application of dairy farming mentioned as example of analysing the composition of the milk per cow and during the milking session, and in particular of monitoring the milk cycle integrally and of achieving an added value for the whole cycle. The measurement results on the basis of the invention enable a monitoring in respect of inter alia:

- the milk quality such as: fat, protein, lactose (possibly including determining of details, for instance fatty acid composition and protein components)
- energy and feed balance on the basis of inter alia urea and ketone bodies
- udder abnormalities on the basis of cell number (and cell differentiation) and blood traces
- cow condition on the basis of variations in component composition and other components
- biological activity such as oestrus on the basis of hormones and other characteristics
- stall behaviour on the basis of average and extreme and individual cow behaviour
- individual and regional performance on the basis of comparison of dairy farms.

The measurement results and/or monitoring results can be used for immediate control (destination of the milk and other actions during milking) as well as for

aspects typified by a longer (permitted) response time, including matters concerning:

- animal health
- genetics
- product liability, quality of production cycle and dairy production
- animal feed
- manure and land management
- product differentiation
- other, for instance meat sector, diary farm equipment.

In the analysis per milking session and accurate management of diverse information flows, a more precise control of the milking installation, feed dosage, milk destination and the like can take place in known controlled manner.

The automatic process input parameters include (see for instance figure 12):

- cow identification
- feed dosage
- parameters of the milking installation
- recording of the milk composition, milk flow rate and milk volume, conductivity, contamination, temperature and individual behaviour of a lactating animal

- gathering of animal data to milk composition of milk in the tank

- destination; tank (respectively high quality and low quality).

The milk-monitoring information system to be set up on the basis of the invention can provide and/or monitor control tasks wholly independently, in combination with reporting to a central data processing system. In the case of control at the farm can be envisaged specific feed, separate destination for the milk, individual adjustment of the milking installation, a change in the accommodation of the cow and so on. The diary farmer may have to perform manual operations at an alarm signal.

The other process information, which can be recorded during milking and which can optionally be input manually into the device according to the invention, relates to udder damage and other physiological evaluation and empirical data identifiable by the farmer.

Data to be input before or after milking relates inter alia to:

- recording of udder treatment

- recording of individual bacterial test

- recording of indicator signal for particular interventions and the use of medicines

- other data, including for instance regular monitoring by inspection agencies.

The criteria of the milk-monitoring information system therefore include objective measurement results, experience, physiological timing, results of internal

and external measurements, monitoring, control, statistical evaluations and other aspects. Such a system can be deemed a continuous learning and management system in which the dairy farmer, as a trained professional, can play an essential part and with which he can increase his skills.

The software embodiment of a system according to the invention can develop into an expert system on the basis of for instance neural networks, multivariation analysis and other forms of data-warehousing and data-mining.

Use can be made of a white source with monochromator of known type. Use can also be made of sources and detectors which individually or in combination define diverse spectral measurement windows.

Use can for instance be made of a number of light conductors to guide the light from a source (for instance from a monochromator) to the measurement window of the source.

The practical implementation of the device according to the invention will be based on the use of a signal processing unit into which data can be entered manually on the one hand and in which data originates from the sensor on the other. The signal processing unit can be coupled to other such signal processing units or pass its data to a central signal processing unit, for instance via a date transmission line, such as a telephone line, or the like.

Implementation of the invention results in an added value for the following interest groups in the above briefly described cycle:

1. dairy farmer (better control, lower cost-price, higher yield)

2. milk-monitoring agency (lower cost-price, better information, rapid response)

3. companies and organizations involved in the development and marketing of genetic production such as sperm, embryos, livestock (better and more detailed information)

4. veterinary services (fast and better information and feedback)

5. dairies (control on the basis of quality, lower cost-price, higher quality of the half-product and the end product)

6. animal feed suppliers (more detailed insight, improvement of conversion)

7. supplier of milking plant (higher-grade system, extra control systems and better feedback)

8. supplier of farm information and management systems (increase in content, new products)

9. supplier of communication systems (new markets and transmission)

10. information technology sector (development of software, data analysis and new product)

11. policy-making bodies (better and detailed insight, better control and monitoring)

12. environmental interest (minimizing of environmental impact)

13. instrument makers (new technology and new products)

14. installation contractors (additional activities)

15. service organizations (new activities)

16. inspection organizations (higher level monitoring function)

17. validation and analysis research and development (increase in content-based and new tasks)

18. associated sectors (meat sector and calf sector; better information)

19. relation to other sectors (suppliers of other systems, sensors and cow recognition)

20. further developments (further differentiation and composition, bacterial analysis, breath analysis, relations with faeces and urine analysis)

21. standardization (new standards)

22. other parts of the cycle (training, research and development)

23. further spin-offs.

Use can for instance be made of an embodiment in which the suction means comprise a ring of holes connecting onto a suction pump around the active outer surface of the source and/or the sensor.

In order to be able to realize an optimization by optical means which can improve the signal/noise ratio, the device can be provided in a particular embodiment with a grey filter, for instance with the attenuation of

1 decade, for moving optionally in and out of the radiation path.

According to a special aspect of the invention the distance between the active end surfaces of the source and of the sensor is adjustable. Thus can be achieved that the sample for measuring will have a layer thickness which is adjustable to correspond with a desired thickness. The volume reflection or the transmission is thus determined by a well-defined layer of the sample. The thickness of the applied plastic foil material of the plastic bag will be small in proportion to the layer thickness of the sample for measuring, or can be compensated by pre-measurement.

The sample holder must be positioned and filled such that the liquid or the solid of the object for measuring is separated by the force of gravity from the air or the gas in the sample holder such that the object for measuring is situated between the measuring surfaces.

Essential for a high sensitivity of the analysis device is the largest possible optical path through the sample/object for measuring. The maximum length of the optical path is determined by the permissible signal/noise ratio. In a transmission measuring device this can be adjusted by adjusting the distance between the source and the sensor; there is no possibility of adjustment in volume reflection measurements, but the distance is determined by the distance between the concentric lighting source and the sensor surface. The distance is further determined by the optical properties, the scattering properties and the absorption properties of the sample.

As calibration system an optically neutral density filter with known transmission characteristics can be arranged in the optical path. This can be used in determining a dynamic measurement range.

The diameter of the light beam in the transmission measuring arrangement can be adapted to the geometry of the object for measuring, or dimensioned, in particular be so small, such that position-dependent variations in the composition of the object can be scanned by positioning the object relative to the radiation beam.

It is for instance possible here to envisage monitoring or scanning the slabs of tooth material in a cuvette-like measuring arrangement or packed in said plastic bag so as to determine variations in the mineral content.

In respect of faeces, measurements are performed with the described measuring arrangement in the wavelength range of 850-1650 nm with a monochromator setup on samples of human faeces of patients without specific diet beforehand. An RMSEP of 1.3% was herein found to be possible without any correction for fat in the range of 1-20 wt %. This demonstrates that the system according to the invention can be applied in research into food conversion.

The field of application for the present invention mainly referred to in the foregoing has been diary farming. It is noted that the invention is likewise applicable in other fields, such as vegetable and fruit analysis, analysis of faeces, manure, urine, slabs of tooth material etc.

The invention will now be elucidated with reference to the annexed drawings. In the drawings:

figure 1 shows a broken-away perspective view of a mould in which a number of elements are received for manufacture of a sensor according to the invention;

figure 2 shows the finished sensor removed from the mould of figure 1 and without a source and a photosensor;

figure 3 shows an exploded view of a volume reflection spectrophotometer measuring head with LEDs and sensor chip;

figure 4 shows a transparent perspective view of the finished measuring head of figure 3;

figure 5 is a broken-away perspective view of a possible arrangement of a transmission spectrophotometer;

figure 6 is a view corresponding with figure 5 of a volume reflection variant;

figure 7 is a perspective view of another variant;

figure 8 shows a partly transparent side view of a following variant;

figure 9 is a partly broken-away perspective view of yet another variant;

figure 10 is a partly broken-away perspective view of a reflection variant with a transparent measuring window;

figure 11 is a partly broken-away perspective view of the so-called milk collector of a milking apparatus with a device according to the invention;

figure 12 shows a block diagram representation elucidating a possible functionality within the scope of the invention;

figure 13 shows a block diagram view in a slightly modified variant;

figure 14 shows a schematic view of a device according to the invention based on a monochromator;

figure 14A shows the end view of a source and photosensor integrated to form a measuring head;

figure 14B shows an end view of the slit plate of the monochromator according to figure 14;

figure 15 shows in cross-section the detail XV of figure 13;

figure 16 is a partly broken-away side view of an integrated source and photosensor;

figure 17A shows in cross-section a transmission measuring arrangement with a separated source and photosensor;

figure 17B shows an end view of the photosensor of figure 17A;

figure 17C shows an end view of the source of figure 17A;

figure 18 shows a longitudinal section through an integrated head comprising source and photosensor;

figure 19 shows a measuring arrangement based on volume reflection;

figure 20 shows an arrangement based on both volume reflection and transmission;

figure 21 is a perspective view of an embodiment of a device according to the invention;

figure 22 is a partly broken-away perspective view of the device according to figure 21 with a plastic bag filled with a sample and placed between source and sensor;

figure 23 shows a perspective view broken-away in different manner of the configuration of figure 22;

figure 24 shows a graph elucidating the choice of sources and sensors with specific characteristics; and

figure 25 shows a graph of regression of faeces, on the basis of which, in the manner shown in figure 21, a choice is made for at least one source and at least one sensor with a characteristic corresponding to a parameter for measuring or detecting.

Figures 1, 2, 3 and 4 show the manner in which a particular embodiment of an integrated source and photosensor with associated optical structure can be manufactured. Placed centrally in a round cup-shaped mould 1 is a perspex cone 2 and a perspex cylinder 3 placed co-axially therewith. The spaces between respectively cone 2 and cylinder 3 and cylinder 3 and the standing wall of mould 1 are then filled with a plastic mass curing to an opaque ring respectively 4, 5. After curing of plastic rings 4,5 the thus integrally formed unit 2, 3, 4, 5 is removed from the mould. This is the stage shown in figure 2.

Figure 3 shows positioning of a disc-like ring 6 which bears a ring of light-emitting diodes as LEDs 7. This ring 6 also fulfils the function of printed circuit board to which LEDs 7 are soldered, which printed circuit board also carries an electronic circuit for controlling the LEDs and processing the signal from chip 8. The nature of these LEDs 7 will be further discussed below. LEDs 7 are placed such that they can emit their electromagnetic radiation via cylinder 3.

A photosensor chip 8 is arranged on the upper surface 9 of cone 2.

A curing plastic mass 11 is subsequently also placed in the manner shown in figure 4 between the upper surface 10 of unit 3, 4, 5 and the lower surface of ring 6 such that all described components form an integrated unit 12. In the described manner this unit or head 12 comprises a source of electromagnetic radiation in the wavelength range of 300-2500 nm consisting of the LEDs and perspex cylinder 3. The effective radiation-generating source is formed essentially by the annular lower surface 13 of cylinder 3. The lower surface 14 of cone 2 forms together with chip 8 a photosensor with entrance window 14.

As will be further discussed below, the surface 14 can receive electromagnetic radiation generated via surface 13. Head 12 is based on the volume reflection principle, wherein both said surfaces 13, 14 are situated in or close to the milk for analysis.

In the shown ring-shaped configuration the LEDs 7 can be built up of mutually adjacent cyclic groups of LEDs which emit any radiation in a specific wavelength band. The LEDs can be controlled by electronic provisions such that all LEDs of a specific wavelength band are for instance energized in cyclic alternation. Through gating, synchronous detection and other signal processing an electronic signal processing unit to which sensor 8 is connected can then determine which radiant

intensity always corresponds with a given wavelength range.

In respect of the temperature dependence of the LEDs and the detector, temperature sensors (not shown) are integrated with the LEDs and the detector. The central processing unit or CPU can thus carry out a temperature-dependent correction and thus eliminate the temperature dependence. After this correction a "clean" signal not dependent on temperature is obtained.

Attention is drawn to the fact that for the operation of the head 12 it is in principle irrelevant whether the concentric surfaces 14 and 13 act as source or as receiver. The optimal configuration is determined by optimal detection possibilities in relation to radiant intensity and cost-price.

Figure 5 shows a tube 15 in which are situated a schematically represented source 16 and a likewise schematically represented photosensor 17. It will be apparent from the shown configuration, in which source and sensor are located diagonally opposite each other, that this configuration is not based on volume reflection but on transmission through the milk situated in the tube.

Figure 6 shows a tube 18 in which a single source 16 and photosensor 17 are located adjacently of each other. This variant is based on volume reflection.

Figure 7 shows a tube 18 with a bend. In this configuration two sources 19,20 are placed on either side of sensor 17. This variant is based on volume reflection.

Figure 8 shows a conduit 21 with a source 16 and a photosensor 17 which are directed toward each other in the bend of conduit 21. This variant is based on transmission.

In the embodiment according to figure 9 source 16 and photosensor 17 are accommodated in a cavity 23

connecting onto a tube 22. The variant of figure 9 is based on transmission.

In the variant shown in figure 10 sources 19,20 are directed away from photosensor 17. This variant is based on reflection in the milk. Such a per se known measurement is referred to as "reflection measurement". Otherwise than in figure 9, a window 110 is present in the embodiment of figure 10 which is transparent for radiation in the used wavelength range, for instance a window of glass, quartz or perspex/PMMA. Attention is drawn to the fact that the configuration has to be such that sensor 17 cannot sense the mirror images of sources 19,20 via reflection through window 110.

Figure 11 shows a part of a milking apparatus 24. This apparatus comprises a housing 25, milk hoses 26, vacuum hoses 27, a head 12 received in a housing, a temperature sensor 28, level sensors 29,30, a linear actuator 31 which carries a valve 85, and a drain conduit 32. Valve 85, which is shown in figure 11 in its lowest position, can co-act sealingly with the annular bottom edge 86 of a rotation-symmetrical inner jacket 87 which, together with the closed valve 85, bounds a space 88 in which the milk flowing in as according to arrows 89 is collected. The signals coming from the level sensors are passed to a CPU 33 (see figure 12). The signals coming from temperature sensor 28 are also passed to CPU 33. As soon as the level of the milk has reached a determined value, the CPU controls actuator 31 to take up its shown opened position. The milk can then move downward as according to arrows 90 to be drained via conduit 32 for further processing.

The active underside of head 12 is immersed for a time in the milk situated in space 88.

Figure 12 shows that via a central processing unit or CPU 33, which is controlled by a personal computer 34, information exchange takes place with feed dosing unit 35 which connects onto a trough 36, a cow

identification receiver 37 which co-acts with a transponder 38 worn round the neck of cow 39, with milking apparatus 24 and a display and operating unit 40. CPU 33 is further connected to a personal computer 41 with memory 42.

Via respective key units 43,44,45,46 information coming from CPU 33 can be transmitted to a signal processing and presentation unit 47, a processing unit 48 and processing unit 49 and a processing unit 50.

The signal processing unit and presentation unit 47 serves to present to the farmer the data relevant to him relating to the milk given by cow 39. This is for instance the total amount of milk from one milking session, fatty acid content, protein content and other important parameters. Via signal processing unit 48 selected, medically significant data can optionally be transmitted via a telephone modem 51 to a veterinary surgeon. Via signal processing unit 49 data which if desired is selected in other manner can be transmitted to national institutes, while signal processing unit 50 can transmit data in analogous manner via modem 51.

Attention is drawn to the fact that the veterinary surgeon, on the basis of the incoming data and after automatic or personal analysis, can transmit a return message to the farmer via modem 51 and signal processing unit 48, for instance with a presentation by means of unit 47.

Two separate signal processing blocks can be distinguished, i.e. block 90 relating to local processing and block 91 relating to data-acquisition.

Figure 13 shows that the milk carried via conduit 32 to a tank 52 passes head 12 which is accommodated in a unit 53 shown in figure 15 with a reciprocally driven piston 54 which periodically drains the milk entering via conduit 32 (arrow 55) to a conduit 56 (arrow 57). Reference is made in this respect to figure 15 in which detail XV is shown on larger scale.

Figure 14 shows an analysis device 57 according to the invention. Otherwise than in the case of head 12 according to the above stated specification, a substantially "white" radiation source 58 is used in device 57 which via a known monochromator generates in periodic variation with time electromagnetic radiation with wavelength changing periodically in time to a bundle 62 of glass-fibres 63 via an exit slit 61 present in a plate 60. Use is made for this purpose of a number of fixed mirrors 93,94,95,96 extending the path length of the radiation beam 92 and a reflection grating 98 driven for periodic pivoting as according to arrow 97. The drive for grating 98 is not drawn. The respective glass-fibres 63 serve as radiation conductors and debouch on a cylinder 64 manufactured from PMMA (perspex), glass or quartz which forms part of a head 65. The end surfaces 66 serve as effective radiation sources. A PMMA cone/cylinder 67 is placed centrally with end surface 68 serving as effective receiver. Placed on the top is chip 8 which via an amplifier 69 transmits its signals corresponding with the detected radiant intensity to a signal processing unit 70, which is connected to monochromator 59 for information exchange and can thus control a presentation unit 71 such that for instance a graphic representation 72 is formed in which the measured radiant intensity or a value of a quantity associated therewith is presented as a function of the frequency or wavelength.

The head shown as well as other components in figure 12 makes use of a number of LEDs as sources for electromagnetic radiation in the frequency bands to be applied.

A LED can produce a high radiant intensity in a comparatively narrow frequency band. The use of monochromator 59 can have the drawback in some

circumstances that the ratio of the energy of a transmitted effective band and the energy in the total band generated by light source 58 is small, so that little energy is available in the band in question. A LED has an effective band width in the order of magnitude of for instance 50-100 nm. Should it be wished to decrease the band width to for instance 10-20 nm for the purpose of a greater resolution, an interference transmission filter can then be added to each relevant LED. A greater resolution may be required particularly in the spectral analysis in the range above 1000 nm. In that case an interference transmission filter can be added to each individual LED in for instance the structure according to figure 4.

Figure 15 shows the detail XV of figure 13.

As in the structure of figure 11, the structure of figure 15 is adapted for a proportional determination of the quantity of milk allowed through. Use is made for this purpose of not shown means (electric, pneumatic), the vacuum of the milking apparatus 24 or the like for reciprocal movement according to arrow 99. The effective volume of chamber 100 can amount for instance to 100 ml. Extending in flush-mounted position on the front surface of the head are conductance-determining electrodes 101,102 which serve to determine the presence of milk at the level of the front surface of head 12. Temperature sensors 103,104 are placed on the inner surface of the plastic housing 105.

Figure 16 shows a practical arrangement. A head 12 is immersed in a conduit 73 via a connecting tube stub 74 into which head 12 fits sealingly. Tube stub 74 bears a flange 75 for coupling head 12 via a support ring 76.

Both the unit 53 according to figure 15 and the unit shown in figure 16 can be added to an existing milking installation. Figure 16 does not show that for

this purpose an existing conduit can be interrupted for incorporation therein of conduit 73.

In both the stated embodiments the flange is connected sealingly to a respective flange 108,75. The sealing is ensured by means of an O-ring 109.

Alternatively, the head 12 can also be arranged by means of a quick-action coupling or MB flanges. This facilitates easy removal of the head, for instance for cleaning and monitoring purposes.

Figure 17A shows a source 77 and a receiver 78. The source comprises a number of LEDs 7 which can emit their radiation via a PMMA cylinder 79. Via an interspace 80 sensor 8 can receive radiation via cone/cylinder 67. The paths of photons are symbolically represented with irregular lines 106. This shows symbolically that the radiation emitted by cylinder 79 reaches cone/cylinder 67 via erratic paths and then only to a small extent. Some photons are intercepted and will therefore never reach said cone/cylinder 67. This interception is represented symbolically with the black spots 107 symbolizing absorption.

It is pointed out by way of orientation that the total average optical path of photons through the milk in space 80 will lie in the order of a maximum of 5 mm. Very good results can hereby be realized.

Figure 17B shows an end view of receiver 78.

Figure 17C shows that the ten LEDs 7 are grouped in a ring.

Figure 18 shows a head 81 in which source and sensor are likewise integrated. The head comprises an opaque cured plastic mass 82 in which a PMMA insert 83 is received. Connecting onto insert 83 is a ring of LEDs 7 which have an axial direction of about 45° relative to the rotation axis 84 of head 81.

At variance with the structure of head 12, only one transparent perspex or PMMA element 83 is applied in head 81 both for guiding outside the radiation generated by LEDs 7 and for guiding inside via surface 84 to sensor 7 the radiation coming from outside.

Figure 19 shows a measuring arrangement which makes use of a source 77 and a receiver 78 of the type shown in figure 17. The arrangement according to figure 17A is based on transmission. The arrangement according to figure 19 is based on volume reflection.

Figure 20 shows an arrangement which provides measuring facilities based on volume reflection as well as measuring facilities based on transmission. The source head 77 is identical to the relevant head according to figure 17, while source/sensor head 85 is identical to the head shown in figure 14.

In this embodiment according to figure 20 the transparent cylinder 64 can act as source. Alternatively or in combination therewith the transparent cylinder 79 can act as source. The cone/cylinder 67 acts as receiver. The arrangement shown in figure 20 provides the possibility of improving the reliability of the measurements.

It is noted that head 65 can also be replaced by a head with a number of LEDs, such as head 12 according to figure 4. The LEDs can herein be tuned or tunable separately or in groups to a frequency range associated with a parameter in order to enable simultaneous determining and/or detection of diverse parameters.

Figures 21-23 show a part of a device according to the invention. The device comprises a frame 122 with two vertical supports 123, 124 in which respective tubes 125, 126 are accommodated for displacement in longitudinal direction. Source 77 is arranged in tube 126; receiver or sensor 78 is arranged in tube 125.

Around the active end surfaces of respectively receiver 78 and source 77 are arranged respective suction chambers 127, 128 which are provided with respective mutually facing flat parallel surfaces 128, 129 which are each provided with a pattern of perforations 130 which act as suction apertures. Suction chambers 127, 128 enclose respectively receiver 78 and source 77 in substantially sealing manner such that the apertures 130 can effectively serve as suction apertures. Connected for this purpose to suction chambers 127, 140 are flexible conduits 131, 132 which are connected to a suction pump 133 drawn schematically in figure 23. By means of clamping screws 134, 135, 136 the tubes 125, 126, and thereby receiver 78 and source 77, can be displaced in longitudinal direction until the active end surfaces of source 77 and sensor 78, which lie in common planes with said surfaces 128, 129, have a desired mutual spacing.

The substance 138 for measuring, which is arranged beforehand in a plastic bag, is placed between the surfaces 128, 129. Tubes 125, 126 are then displaced until surfaces 128, 129 have the desired mutual spacing. Suction pump 133 ensures that via holes 130 the walls of bag 137 are sucked against surfaces 128, 129, whereby they come to lie tautly against the windows of respectively source 77 and sensor 78. Measurement inaccuracies and uncertainties are hereby effectively avoided.

Figure 23 in particular shows the manner in which bag 137 is placed in relation to suction chambers 127, 140 during performing of the measurement in which the source and the sensor are active and are controlled and transmit signals to a central signal processing unit in the above described manner.

The sample holder, which can be embodied in practice as a plastic bag, can be manufactured in practical manner from a foil material which is flexible, optically homogeneous and transparent to the applied wavelengths such that the sample for measuring is closed off to a sufficient extent from its surroundings, can be transported in the holder and can also be stored at low temperatures. The choice of material for the foil bag must be made such that mechanically or manually or in other manner the bag enables operations such as dilution, mixing, homogenizing and other pre-treatments. The combined function of packaging and sample holder must be such that it can be received in the analysis device cheaply and simply without the necessity of pre-treatment or modification and is also suitable, with possibly small modifications, to be arranged in process installations relevant to the object for measuring, for instance a milking installation.

In respect of security of storage and transport a second storage bag can if necessary be applied, into which the sample holder is placed. Feed hoses and discharge hoses can if desired be connected to the holder for the purpose of dilution or the addition of reagents. The chosen foil material can if necessary withstand centrifugal forces which occur in centrifuges in the case of a centrifugal separation in the sample.

In the description following below reference will often be made to milk. However, this is only by way of explanation of a number of principles which are equally applicable to the analysis of the further stated substances for analysis.

Figure 24 shows results of wavelength-variable measurements on 100 different human faeces samples, using a slightly modified setup relative to that shown in figure 23. These were samples from patients with a

great variation in diet, including patients with disorders of the digestive system. The absorptivity is plotted along the vertical axis against the wavelength in nm along the horizontal axis. The dark current is represented by the spectrum indicated with numeral 141.

Absorption peaks can clearly be identified in figure 24, such as at position 142. The absorption peaks are associated with the composition of faeces and the peaks thereof to be tested in the analysis according to the invention.

Making use of a source, at least one LED, which is tuned to the wavelength associated with peak 142 and corresponding sensors in the analysis device according to the invention, a diagnostic evaluation concerning the regression of the faeces is possible on the basis of the analysed parameter. Figure 24 comprises a plurality of absorption peaks. It will be apparent that the quality of the diagnostic evaluation can possibly be improved considerably if more absorption peaks are involved in the analysis. By employing a plurality of LEDs tuned to the different absorption peaks or wavelengths and corresponding sensors in the analysis device of the invention, the quality of the analysis, and therewith the quality of the diagnosis, is improved.

Figure 25 thus shows the regression spectrum based on analysis of all spectra shown in figure 24 after multivariation analysis making use of the commercially obtainable multivariation analysis software program "Unscramble" from Camo of Norway. In this regression spectrum the peak 142 of figure 24 can be clearly discerned as well as peaks which are not immediately discerned upon cursory visual inspection of figure 24. These are for instance peaks 145, 147, 142, 144 and 146 and other peaks. In figure 25 the weighting factor is plotted vertically as a percentage against the

horizontal wavelength in nm. For a determined substance in faeces in the regression spectrum, in this case (raw) fat content, a relation is given which forms part of the analysis resulting in a determination of the fat content in faeces on the basis of the invention. On the basis of the spectra shown in figure 24 and compared to a wet chemical analysis of the fat content of the faeces, it is found possible with the analysis device of the invention to obtain an RMSEP of 1.3% in the range of 1-20 wt %, sufficient to thereby obtain a diagnostic indication for patients.

CLAIMS

1. Measuring head for a device for direct analysis of products, such as milk given by lactating animals, for instance raw milk, processed milk such as fermented milk, yoghurt and the like, faeces, manure, soil, urine, fruit or fruit slices, potatoes, tooth material or slabs of tooth material etc., such that the value of at least one parameter is measured or detected, for instance the total quantity of milk from one milking session, the milk flow rate during milking, the structure, the fat content, the fatty acid composition, the protein content, the protein composition, the number of somatic cells optionally divided to type, urea content, ketone body content, determining of ketone body details, hormone levels, lactose content, blood content, beestings characteristics, which device comprises:

a spectrophotometer with:

a source of electromagnetic radiation with at least one chosen spectral component in the wavelength range of about 300-2500 nm;

a photosensor which is sensitive to at least the first, second and third, and optionally the fourth harmonics or spectral components associated with the wavelengths used, in particular about 300-2500 nm, and which in relation to the product for analysis is disposed relative to the source such that the sensor receives radiation scattered via the product for analysis by transmission, reflection and/or volume reflection; and

a signal processing unit which is connected to the sensor and which can generate signals representative of the spectral composition of the radiation sensed by the sensor; and

a space which is adapted to contain products for analysis, into which space both the source and the sensor debouch with their active surfaces, to which space connect feed and outfeed means for feed and outfeed of products for analysis, which means are adapted to be connected to respectively a supply and discharge of products for analysis, wherein the measuring head comprises the source or the sensor, wherein a light-conducting assembly (2, 3, 4, 5) and a carrier (6) for the source (7) or the sensor (8) are mutually connected to form a unit with the source or the sensor therebetween.

2. Device as claimed in claim 1, wherein the source and the sensor are integrated to form one measuring head.

3. Device as claimed in claim 1, wherein the measuring head has a generally rotation-symmetrical structure.

4. Device as claimed in claim 1, wherein the source has an at least more or less white character for the radiation components used in the range, for instance comprises a halogen lamp or a xenon lamp, and wherein a variable monochromator is added to the source.

5. Device as claimed in claim 1, wherein the source comprises a number of sub-sources which each emit at least one spectral component tuned to a spectral range corresponding with a parameter for detecting.

6. Device as claimed in claim 1, wherein the sensor comprises a number of sub-sensors which are each sensitive to at least one of the relevant stated harmonics or spectral components.

7. Device as claimed in claim 1, wherein the geometric distance between the active surface of the source and the active surface of the sensor amounts to at least 1.0 mm.

8. Device as claimed in claim 5, wherein the sub-sources each comprise at least one LED, or LED laser, polymer LED, polymer laser or the like.

9. Device as claimed in claim 1, wherein the signal processing unit contains an arithmetic software program which is based at least partly on statistical techniques, multivariation analysis and/or neural networks.

10. Device as claimed in claim 6, comprising an Si sub-sensor for the range of about 300-1100 nm.

11. Device as claimed in claim 6, comprising a GaAs sub-sensor for the range of about 800-2000 nm.

12. Device as claimed in claim 6, comprising an Si-Ge, Si-GaAs or other suitable combination sub-sensor.

13. Device as claimed in claim 1, wherein the signal processing unit is adapted for coupling to an electronic identification device.

14. Device as claimed in claim 1, wherein the signal processing unit is adapted for coupling to a central unit to which more similar devices can be coupled.

15. Device as claimed in claim 1, wherein the signal processing unit is adapted to determine the breeding value of an animal on the basis of the value of a number of parameters, for instance the quantity, composition of the milk and the milk flow rate during milking.

16. Device as claimed in claim 8, wherein the source is operated intermittently such that possible adverse influence of interference radiation is reduced.

17. Device as claimed in claim 2, wherein the source or sub-sources and the sensor or sub-sensors are integrated on a semiconductor chip.

18. Device as claimed in claim 1, wherein the milk can flow through the space.

19. Device as claimed in claim 1, comprising measuring means for measuring the values of non-optical parameters, such as electrical conductivity, temperature, viscosity, surface tension.

20. Device as claimed in claims 3 and 5, wherein the sub-sources are disposed in groups in a ring.

21. Device as claimed in claim 2, wherein the source and the sensor are placed concentrically, are mutually separated optically by an opaque first cylinder and are together enclosed by an opaque second cylinder.

22. Device as claimed in claim 21, wherein the source and the sensor are connected via a central first radiation conductor to a second radiation conductor concentric thereto wherein their respective active outer surfaces are connected.

23. Device as claimed in claim 22, wherein the central radiation conductor has a form diverging in the direction of the active outer surface.

24. Device as claimed in claim 23, wherein said active outer surfaces and the corresponding outer surfaces of the first and the second cylinder lie in one common main plane.

25. Device as claimed in claim 22, wherein the radiation conductors consist of a substantially colourless material transparent for the used electromagnetic radiation, for instance perspex/PMMA, glass, quartz.

26. Device as claimed in claim 22, wherein the measuring head is manufactured by moulding liquid plastic curable to a transparent mass in a mould cavity, the form of which corresponds with that of the radiation conductors in the desired mutual spatial relation, together with a connecting bridge between these radiation conductors, causing the plastic to cure to a transparent mass, arranging the cylinders by moulding in

the relevant free cavities a mass which is curable and which at least in cured state is not light-transparent, causing this mass to cure and removing the connecting bridge and optionally further parts, followed by arranging source and sensor.

27. Device as claimed in claim 1, wherein a temperature sensor is added to a radiation source and/or a sensor with temperature-dependent properties, the output signals of which temperature sensor are fed to a signal processing unit to which the radiation source and/or the sensor is connected such that the signal processing unit can form radiation source and/or sensor signals not dependent on temperature.

28. Device as claimed in claim 1, wherein products for analysis or at least a sample thereof can be placed in a flexible holder which is at least practically transparent for the applied electromagnetic radiation, such as a plastic bag, which holder fits into the space for analysis.

29. Device as claimed in claim 28, wherein source and sensor are placed or can be placed with active surfaces or parts thereof against the holder at a predetermined mutual distance.

30. Device as claimed in claim 28, wherein source and/or sensor comprise suction means at least in the vicinity of active surfaces thereof, which suction means tension the holder over the active surfaces during operation.

31. Device as claimed in claim 30, wherein the suction means comprise nozzles arranged in a ring round a centre of the active surfaces and the nozzles are connectable to a pump.

32. Device as claimed in claim 29, wherein the predetermined distance is adjustable.

33. Device as claimed in claim 1, comprising a grey filter which can optionally be arranged in the radiation path from source to sensor and which has for instance an attenuation of 1 decade.

34. Method for calibrating a device as claimed in any of the claims 1-33, which device is based on reflection or volume reflection, according to which method a diffusely reflecting, for instance white or black flat surface is placed at a chosen position at a distance from the source and the sensor, the device is set into operation and the measurement results obtained with the operating device are compared to a predetermined standard.

35. Method for calibrating a device as claimed in any of the claims 1-33, which device is based on transmission, reflection or volume reflection, according to which method a white or fluorescent reference liquid, for instance a suspension with latex particles of a chosen concentration and particle size distribution, is carried into the space, the device is set into operation and the measurement results obtained with the operating device are compared to a predetermined standard.

36. Method for calibrating a device as claimed in any of the claims 28-33, which device is based on transmission, reflection or volume reflection, comprising of placing an empty holder, or a part of the empty holder, into the analysis space of the device, setting the device into operation, storing measurement results and using the measurement results to correct actual measurements for frequency characteristics associated with the holder.

37. Method of producing a measuring head as claimed in claim 1, comprising of: manufacturing a light-conducting assembly (2, 3, 4, 5); arranging a source (7) or a sensor (8) on a carrier (6); connecting the light-

conducting assembly and the carrier with the source or the sensor therebetween.

38. Method as claimed in claim 37, wherein connecting of the carrier and the light-conducting assembly comprises of: placing the source or the sensor substantially against or close to the light-conducting assembly; and moulding (11) the source or the sensor while connecting the carrier and the light-conducting assembly.

39. Method as claimed in claim 37 or 38, wherein manufacture of the light-conducting assembly comprises of: enclosing between opaque elements (4; 4, 5) at least one light-transmitting element (2; 3) transparent for the radiation used.

40. Method as claimed in claim 39, wherein the measuring head comprises the source and the sensor, and manufacture of the light-conducting assembly comprises of: providing light-transmitting elements for each of the source and the sensor individually.

41. Method as claimed in claim 40, further comprising of concentrically arranging the light-transmitting elements (2, 3) and the source and sensor associated with each of the light-transmitting elements during manufacture of the light-conducting assembly.

42. Method as claimed in claim 39, wherein manufacture of the light-conducting assembly further comprises of moulding at least one pre-manufactured light-transmitting element into opaque material (4, 5).

43. Method as claimed in claim 42, further comprising moulding of the light-transmitting element in a mould (1).

FIG. 1

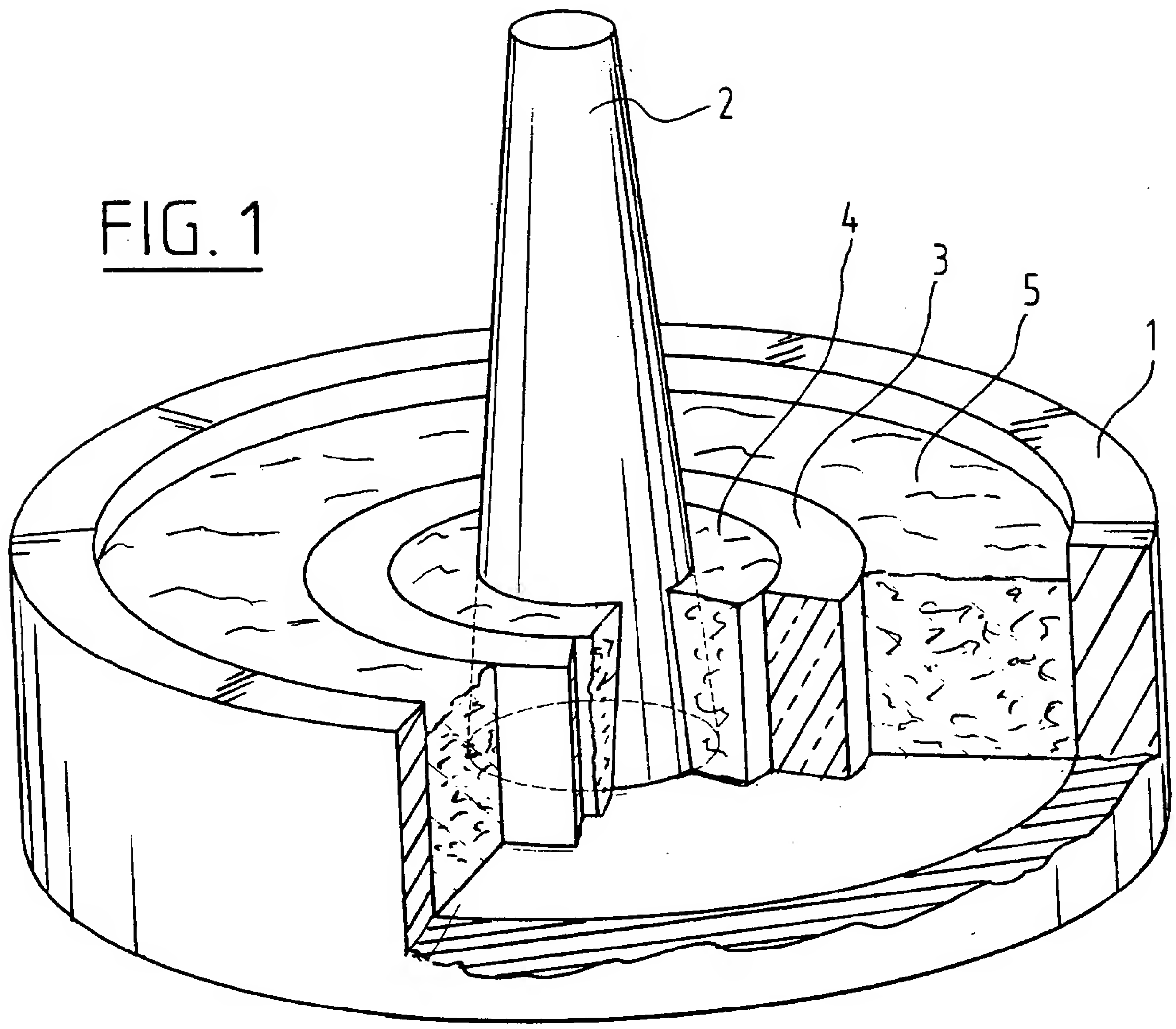
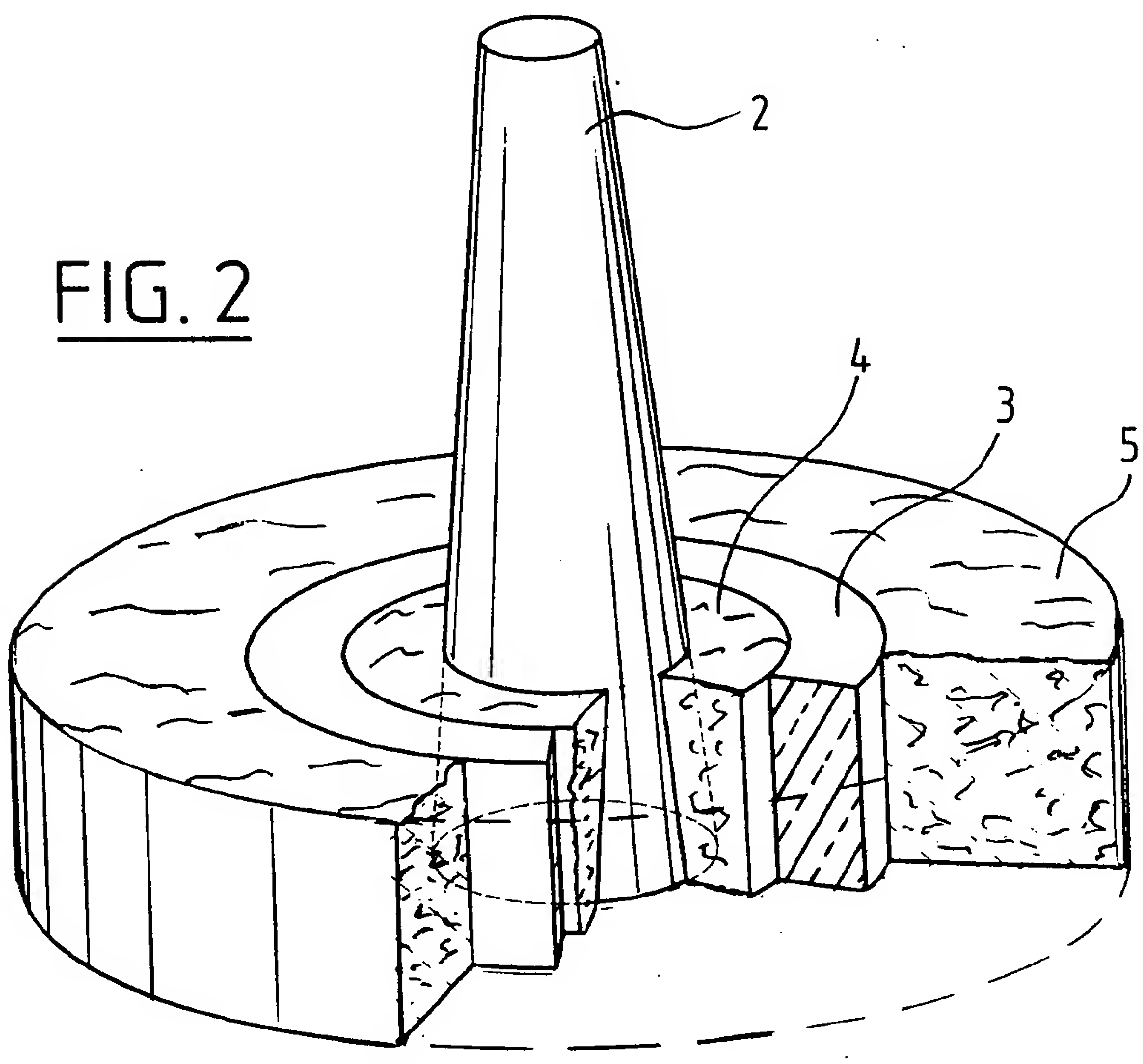


FIG. 2



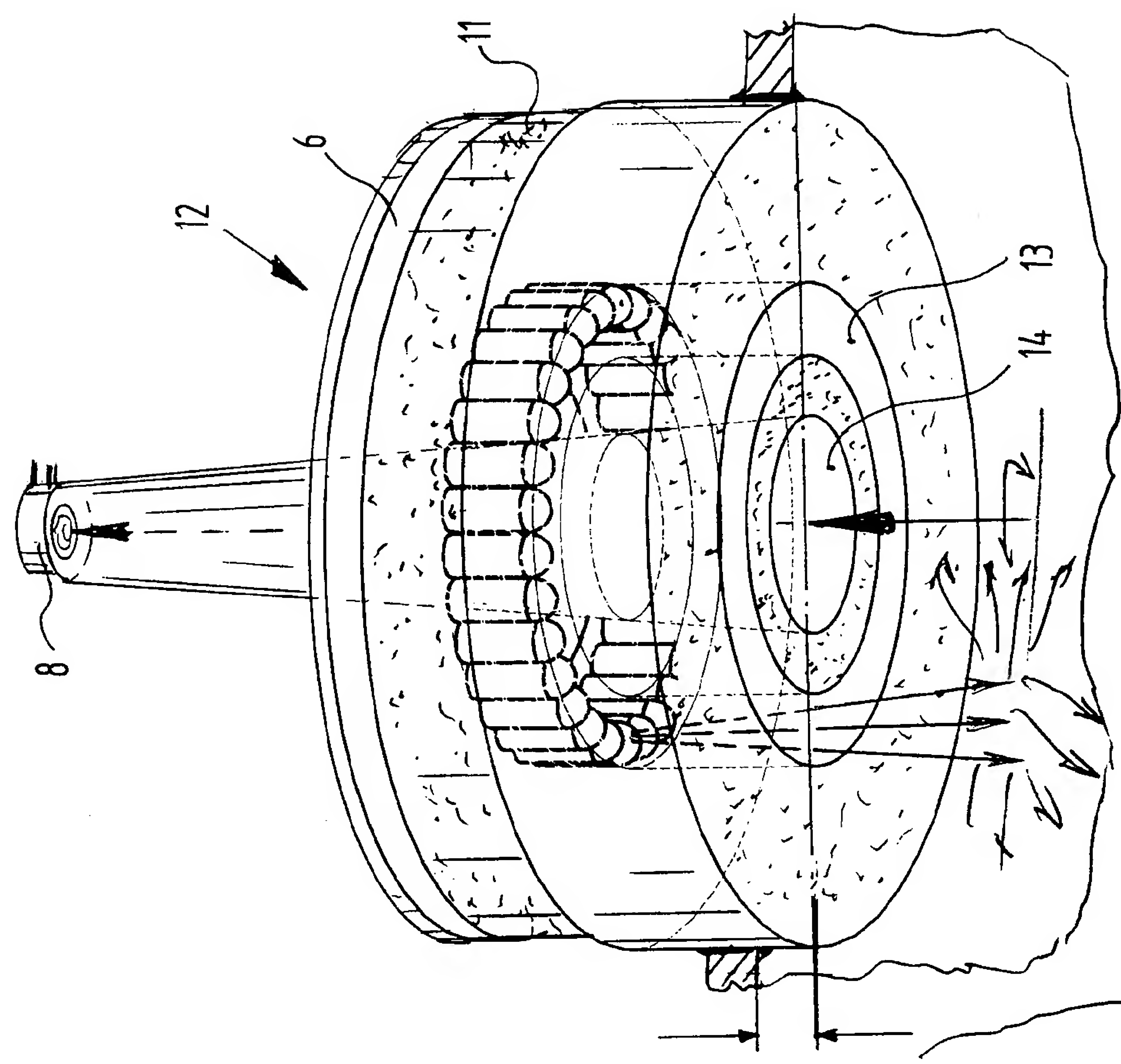


FIG. 4

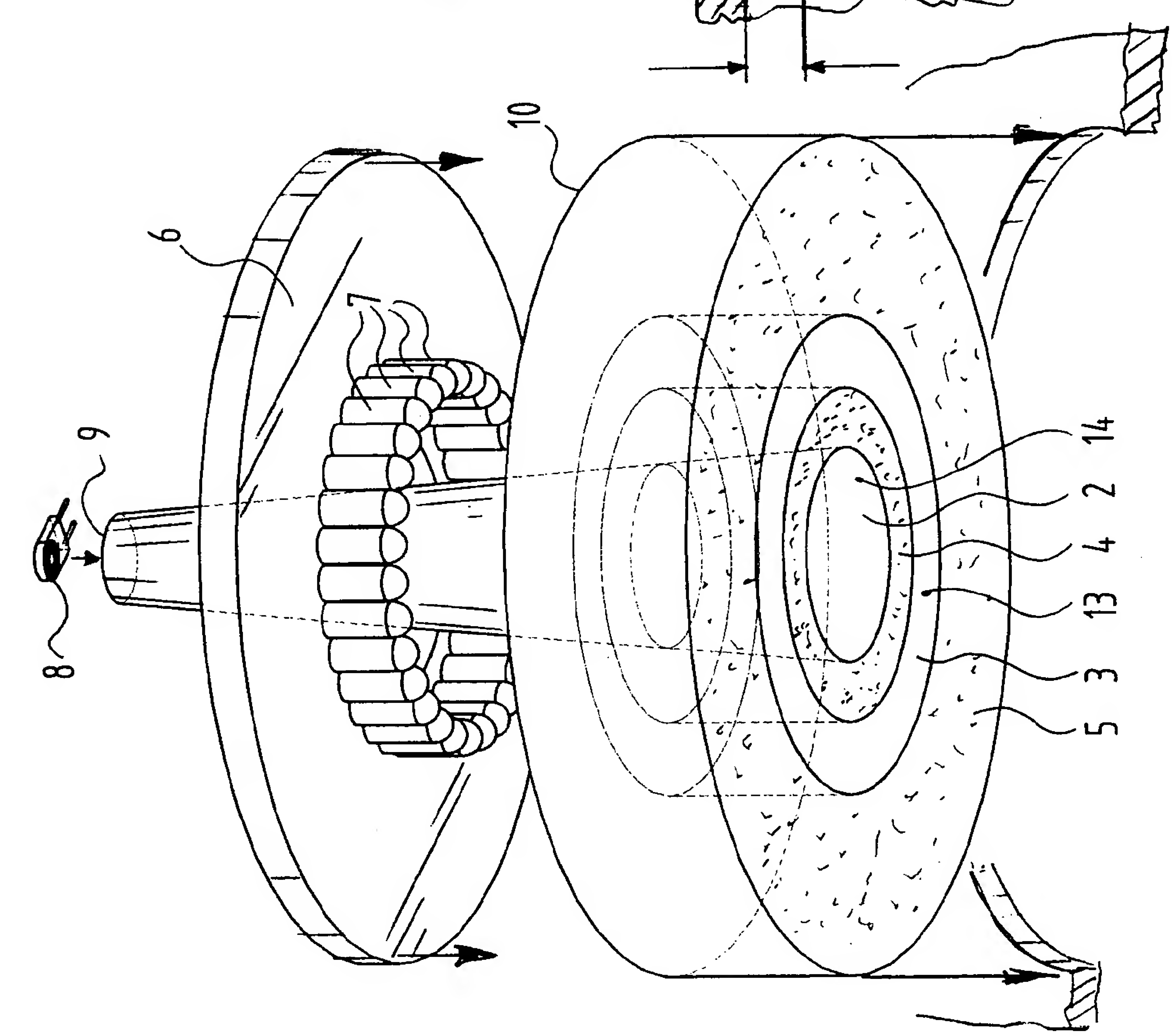


FIG. 3

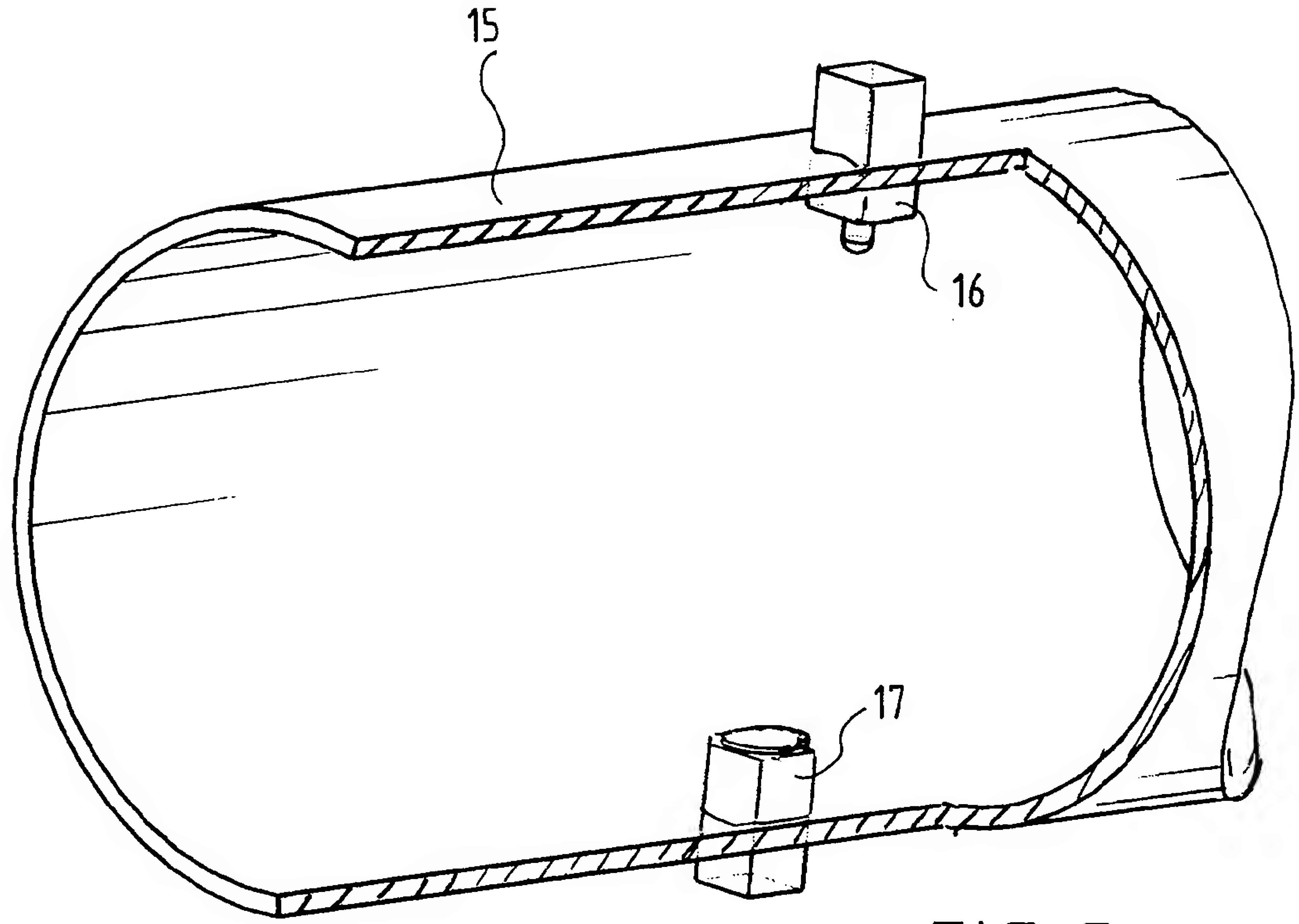


FIG. 5

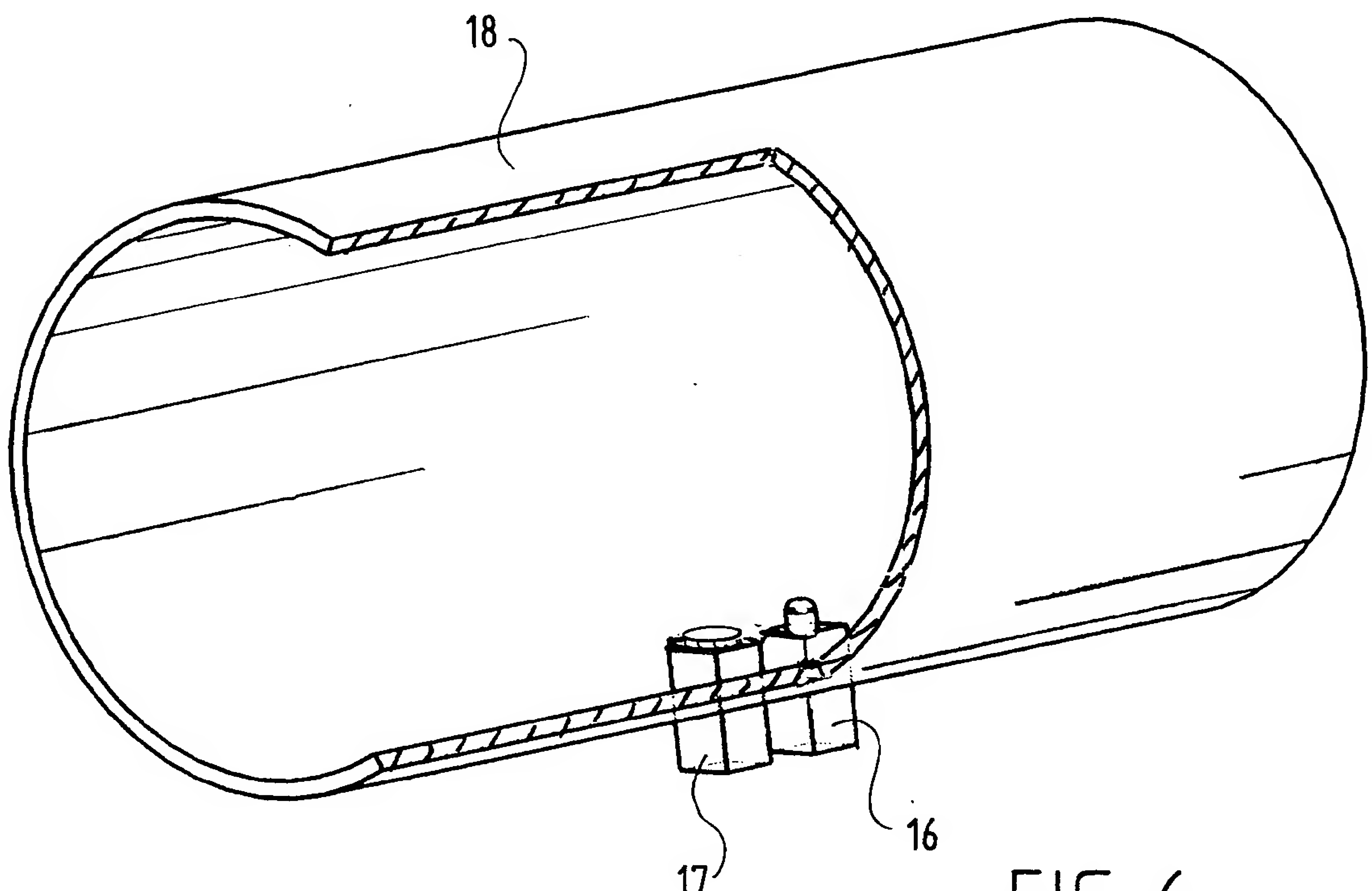


FIG. 6

FIG. 7

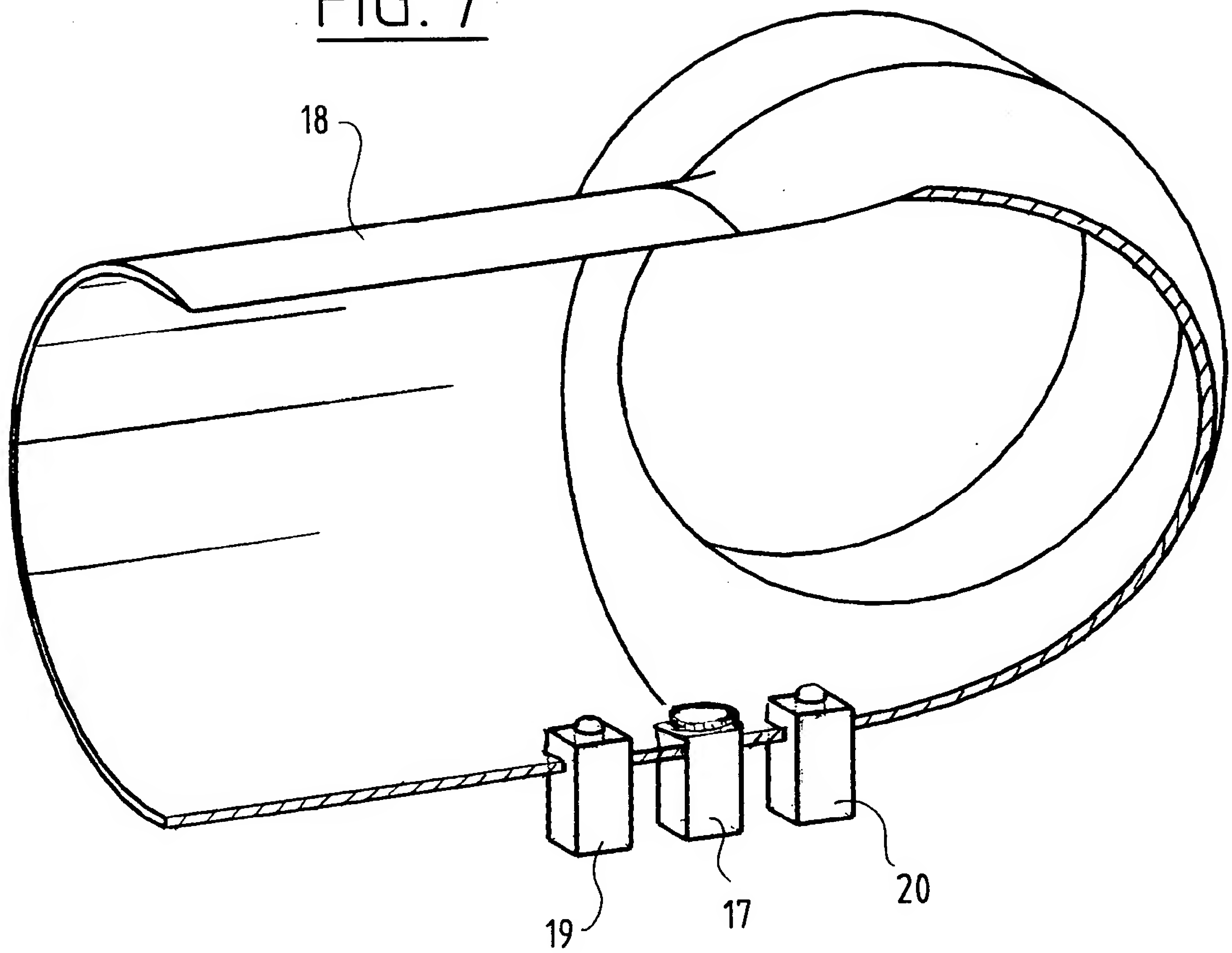
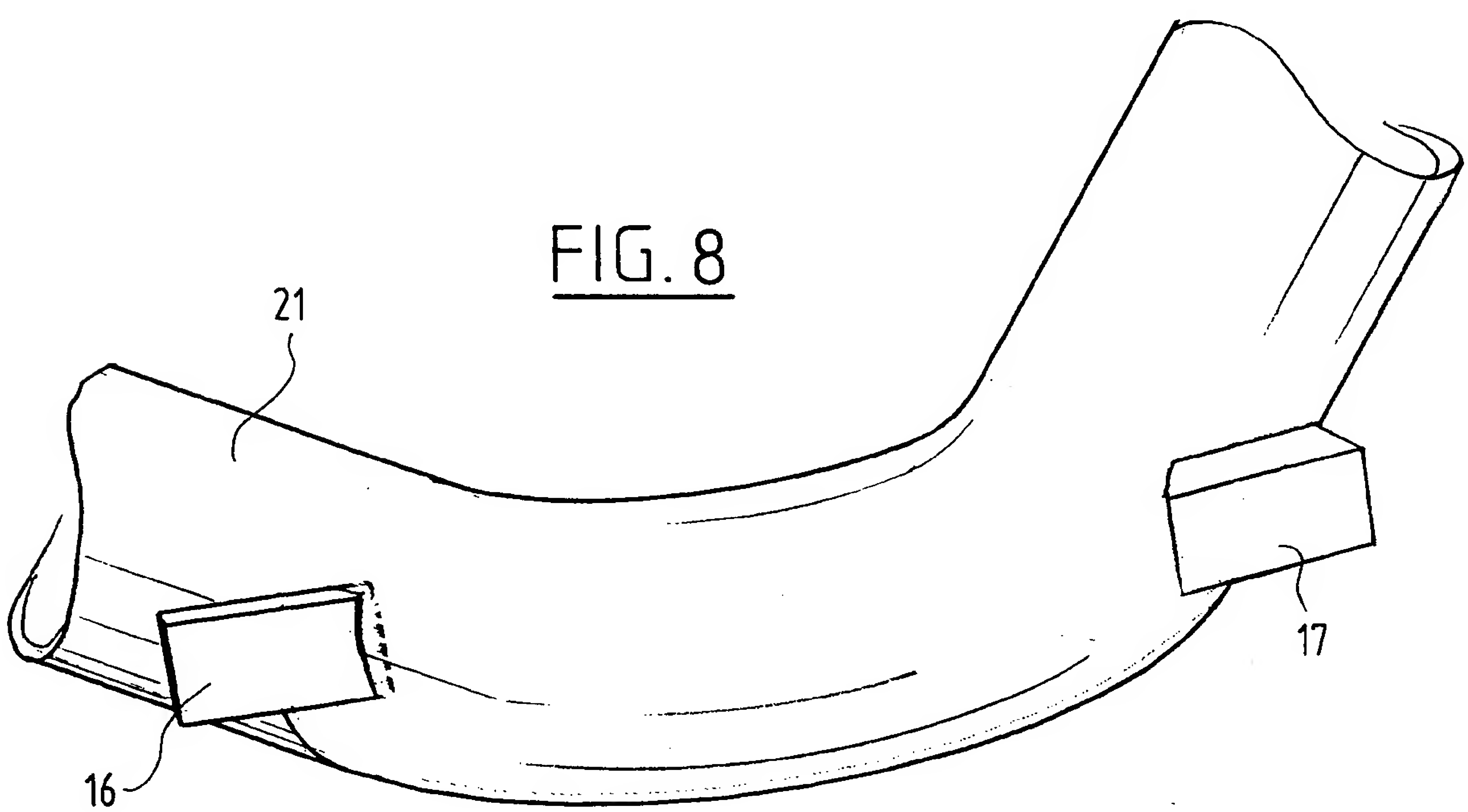


FIG. 8



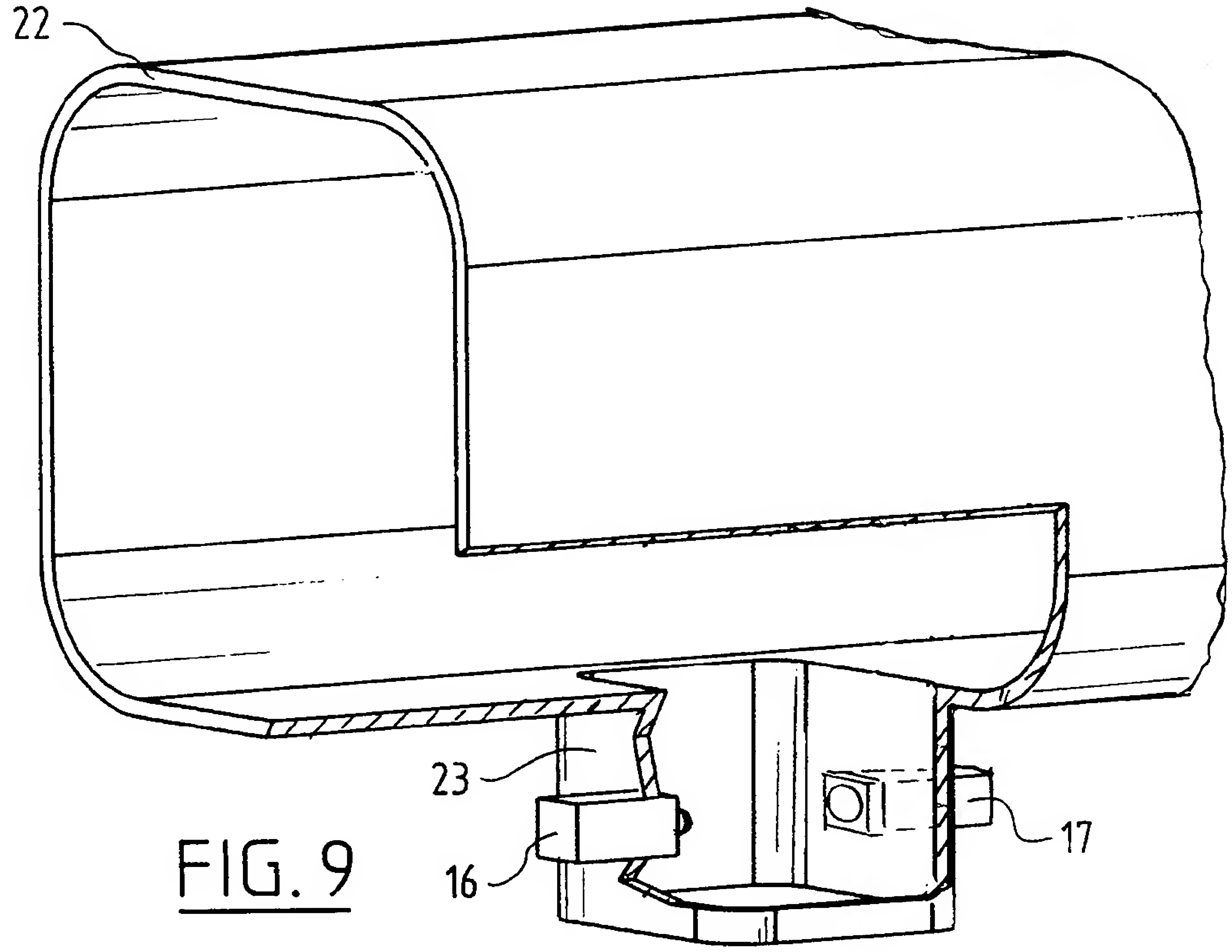


FIG. 9

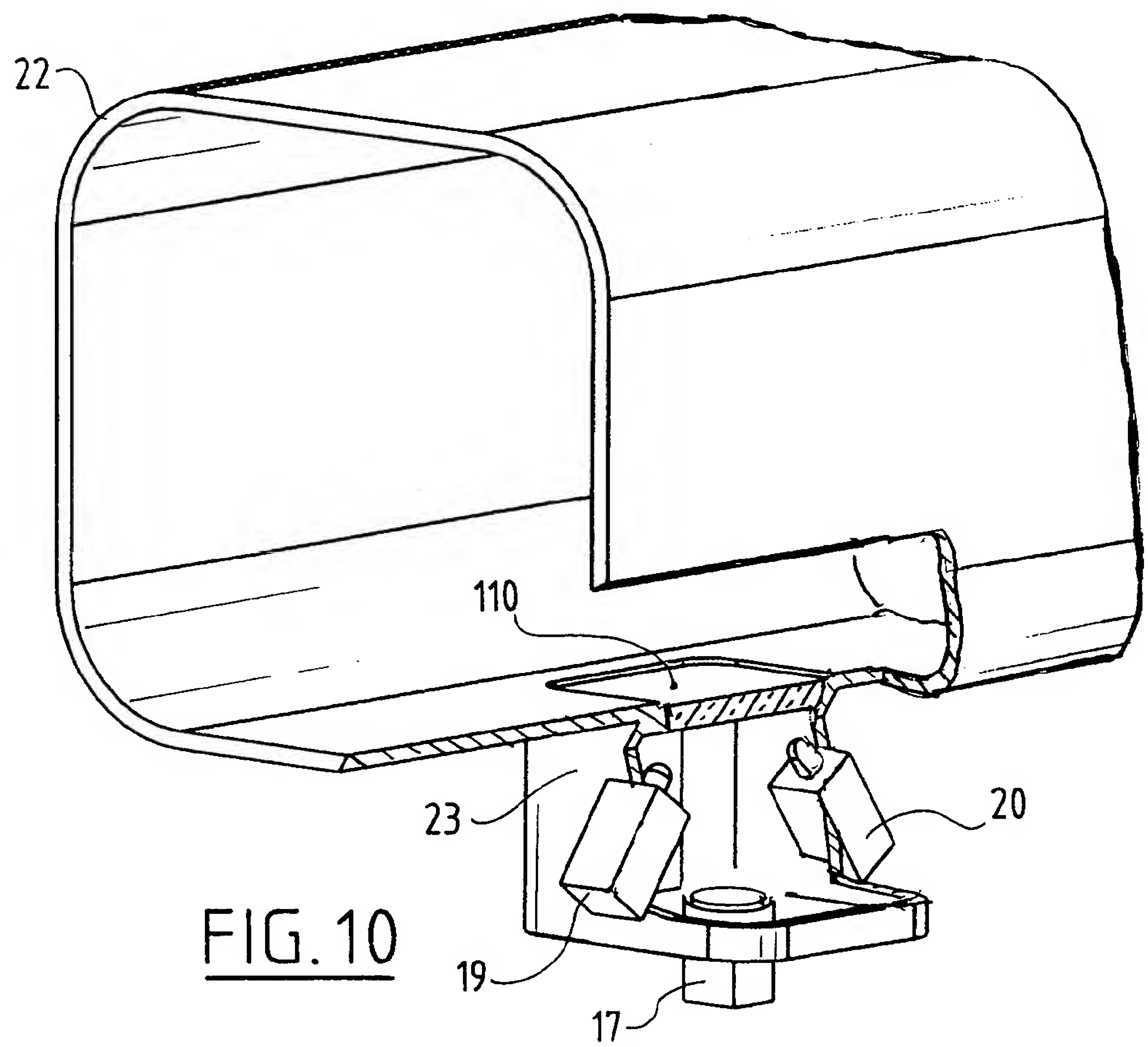


FIG. 10

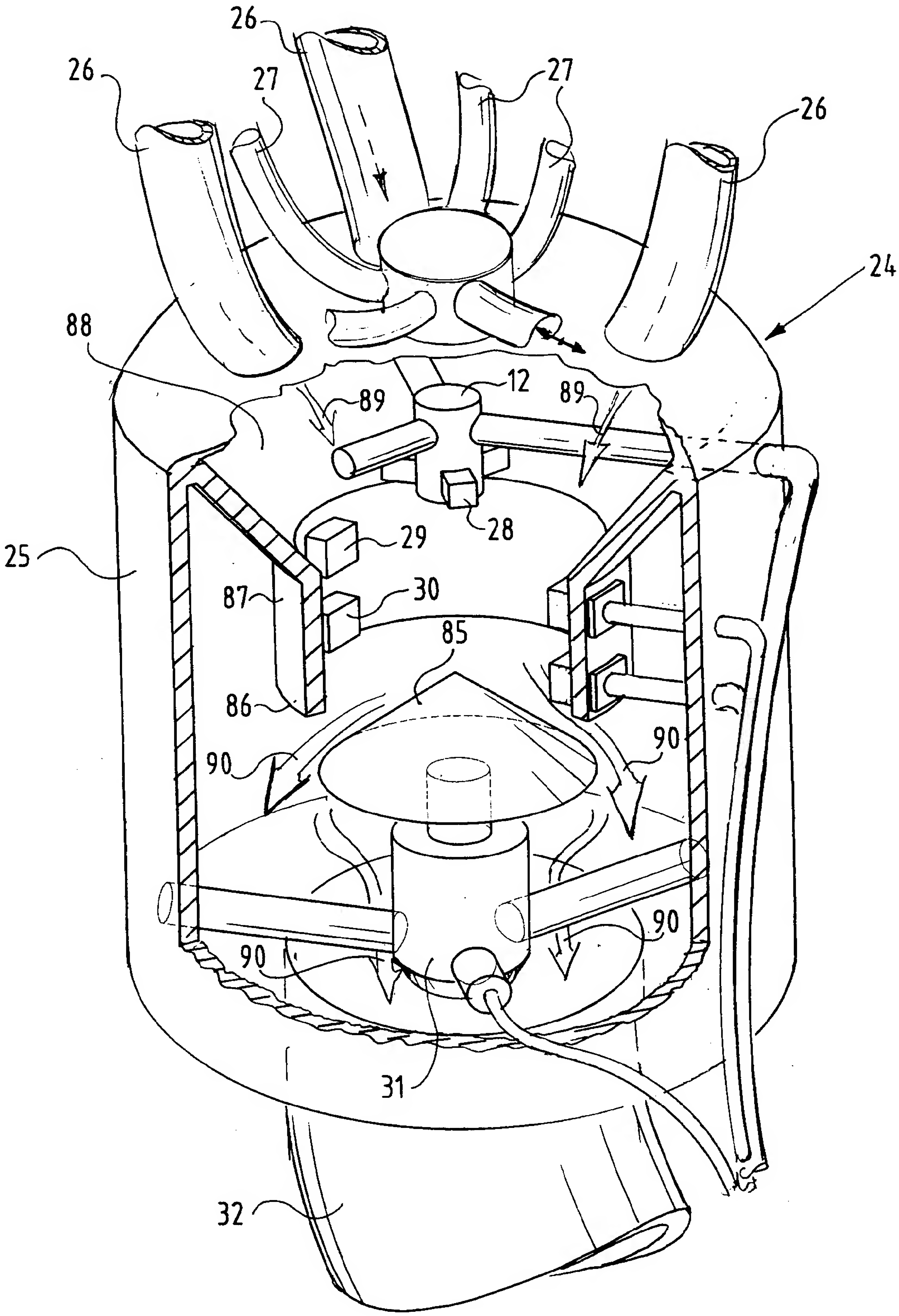


FIG. 11

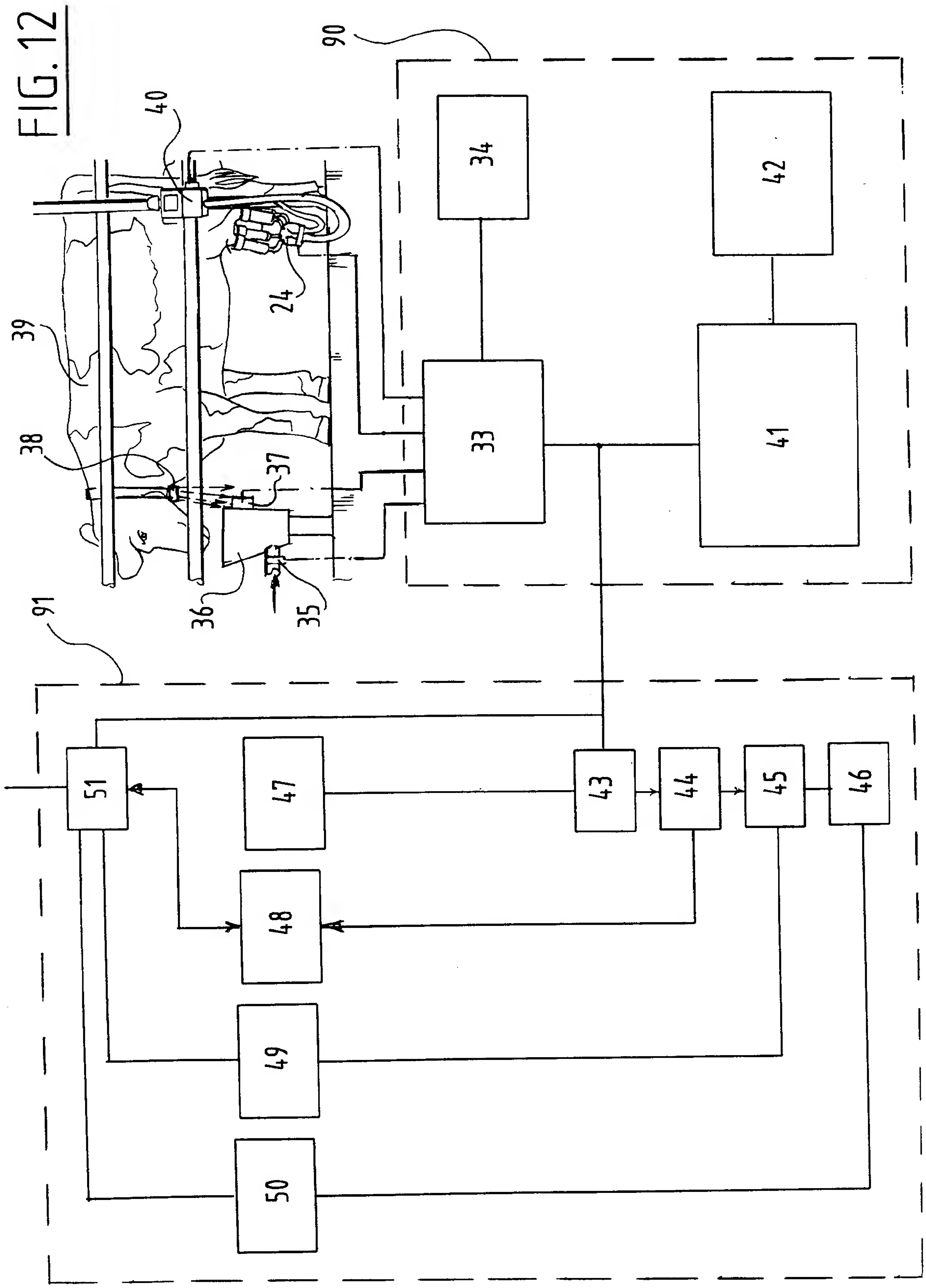


FIG.12

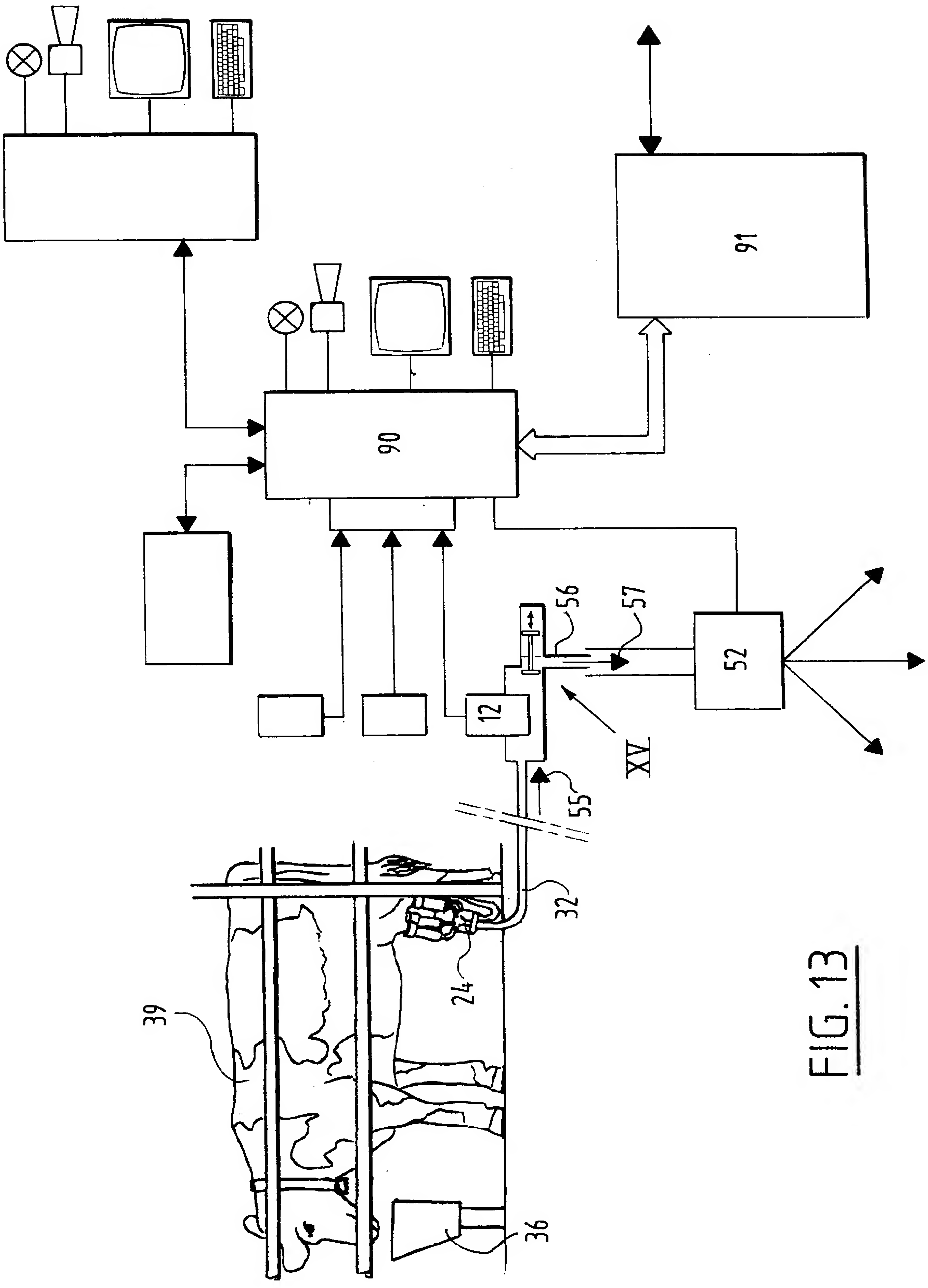


FIG. 13

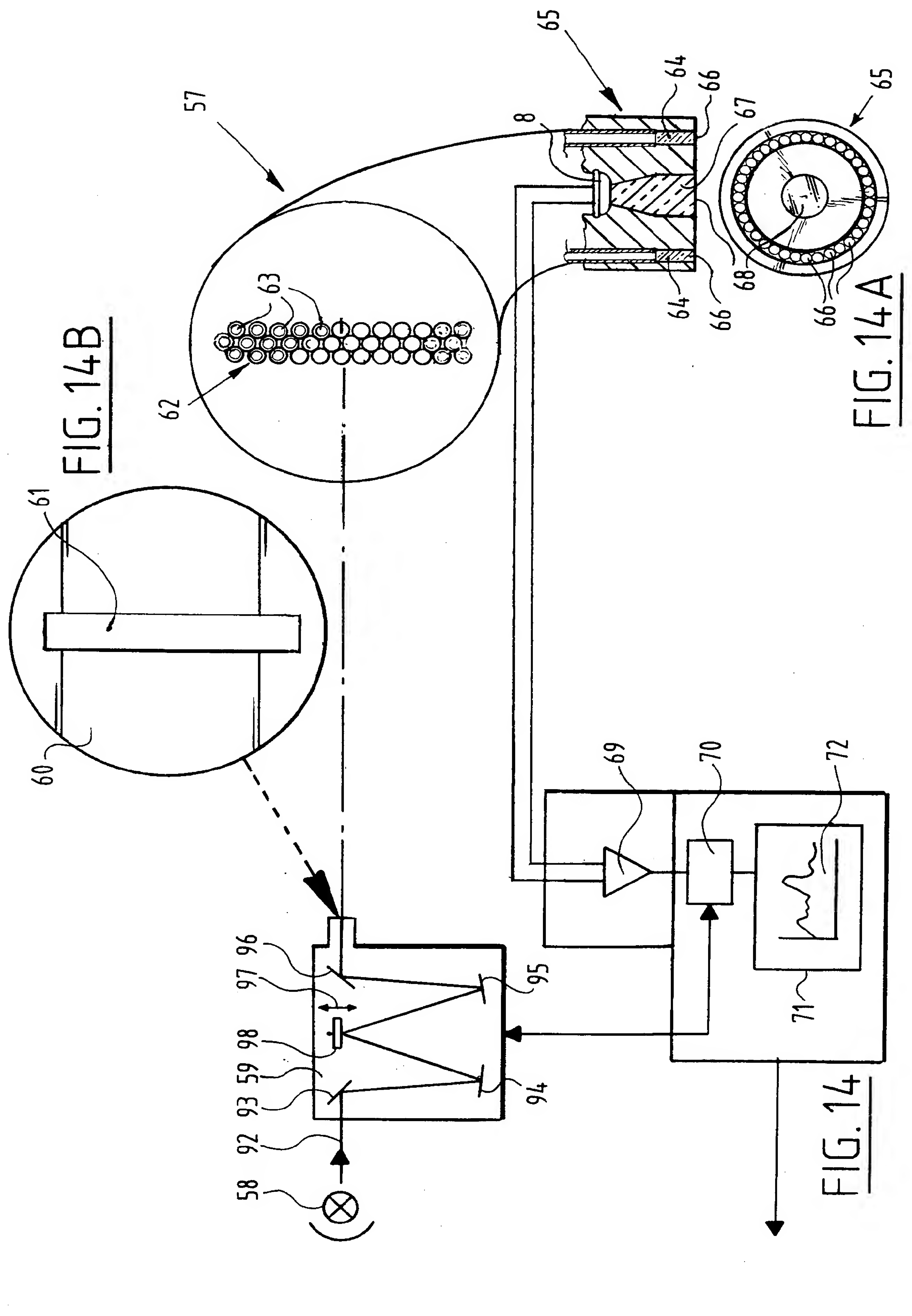


FIG. 14B

FIG. 14A

FIG. 14

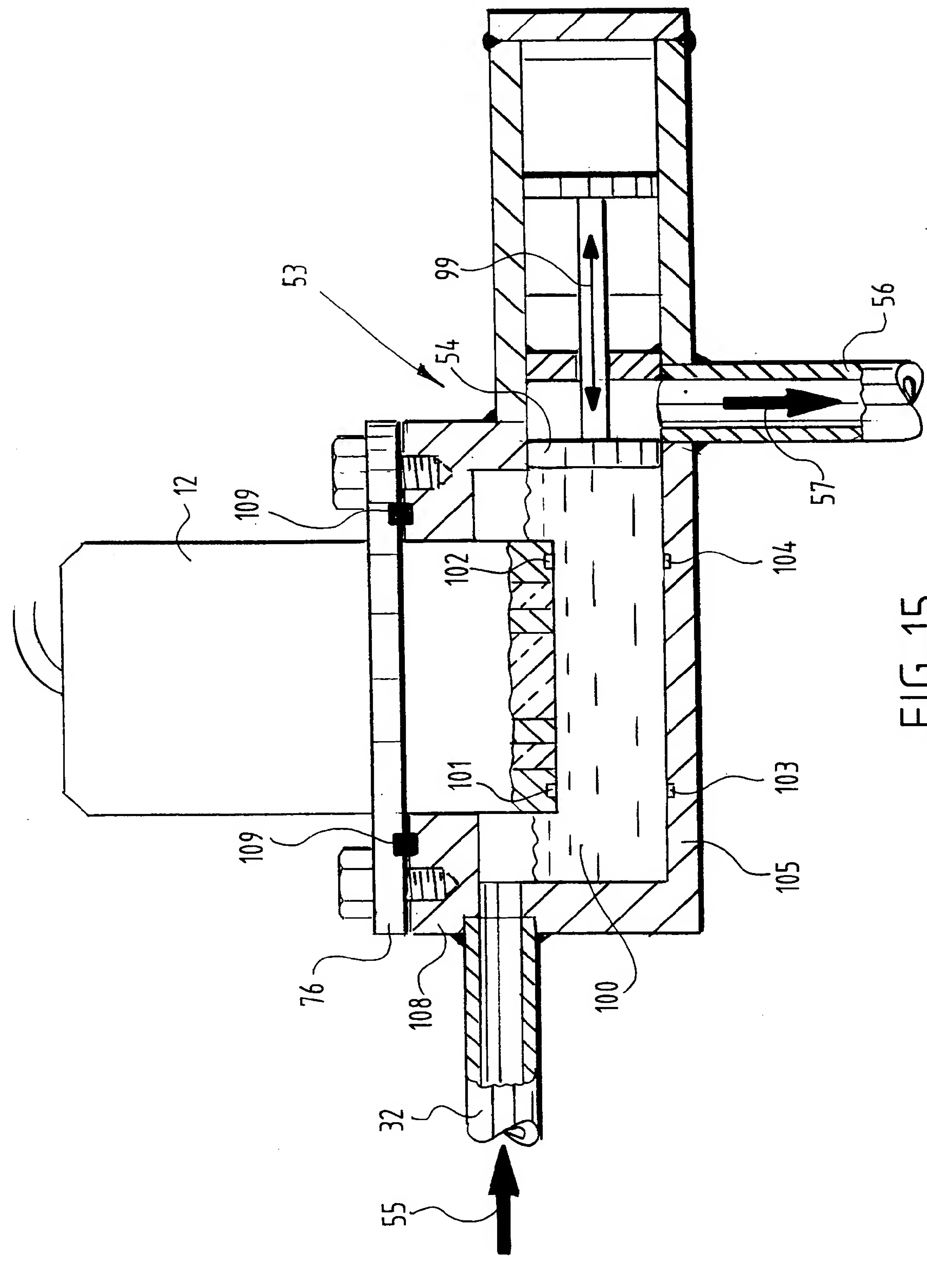


FIG. 15

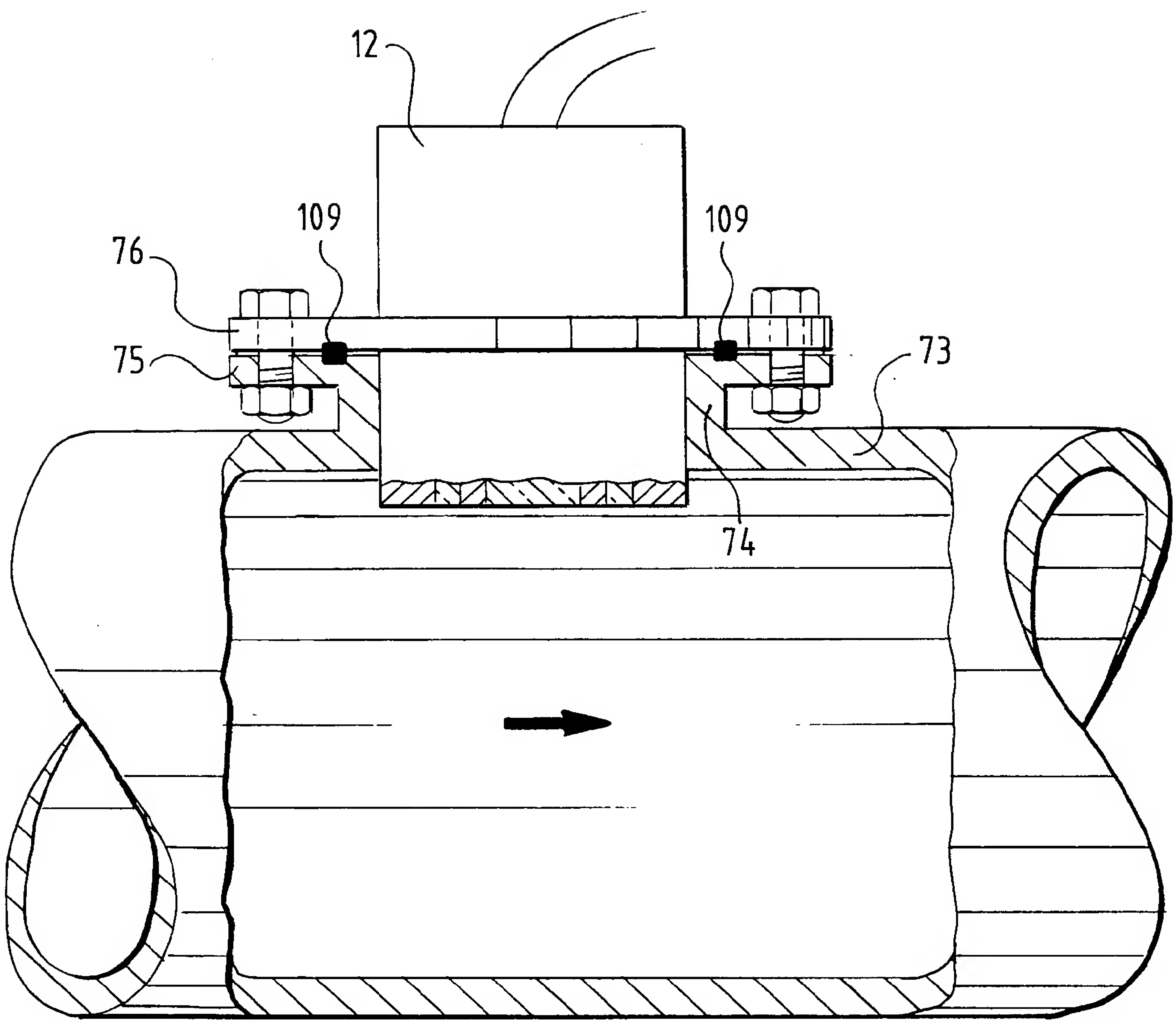


FIG. 16

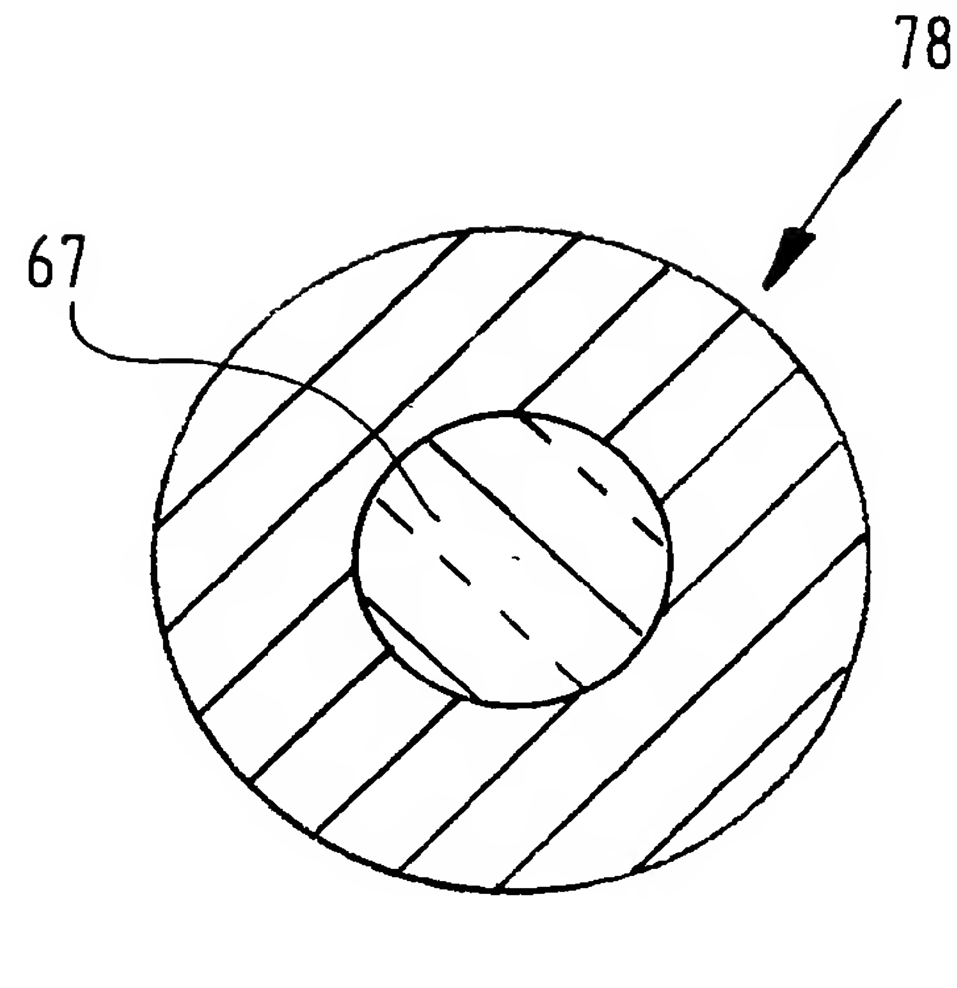


FIG. 17B

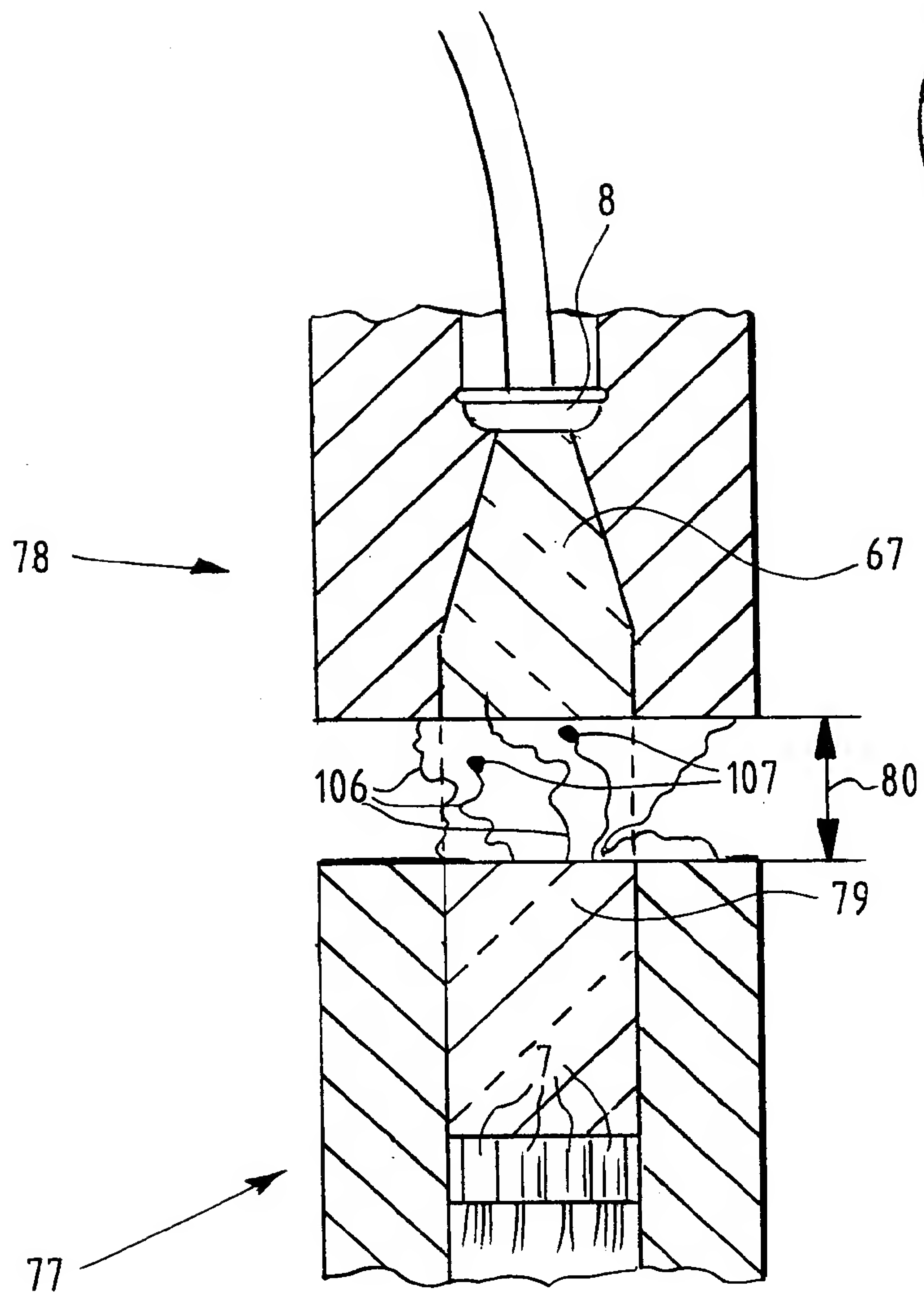


FIG. 17A

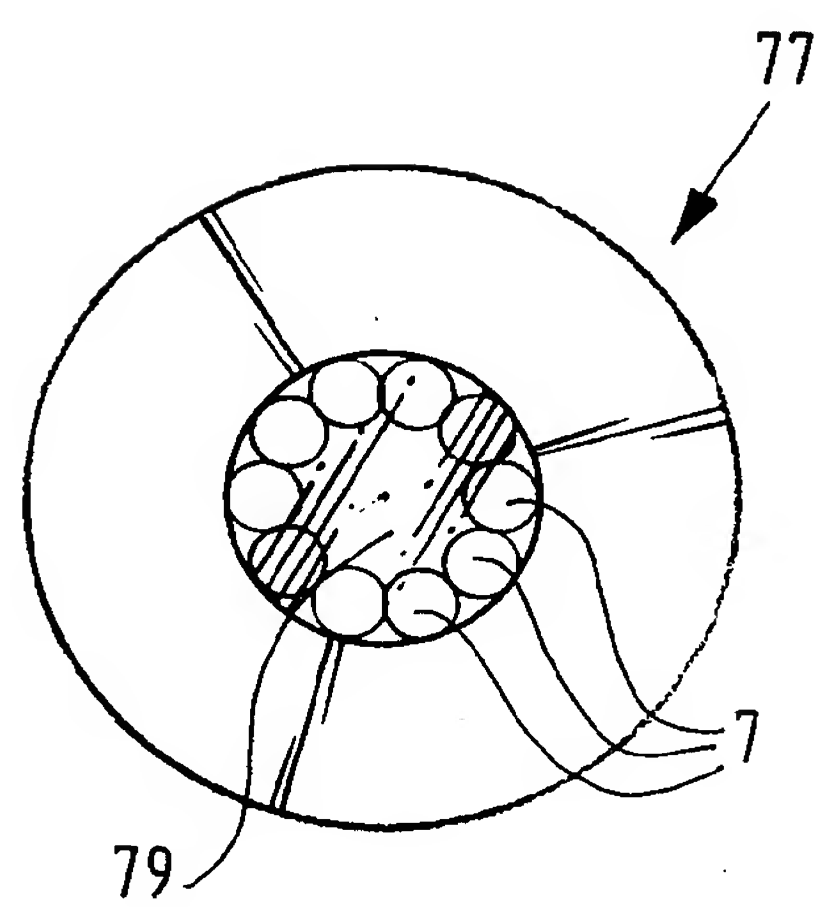


FIG. 17C

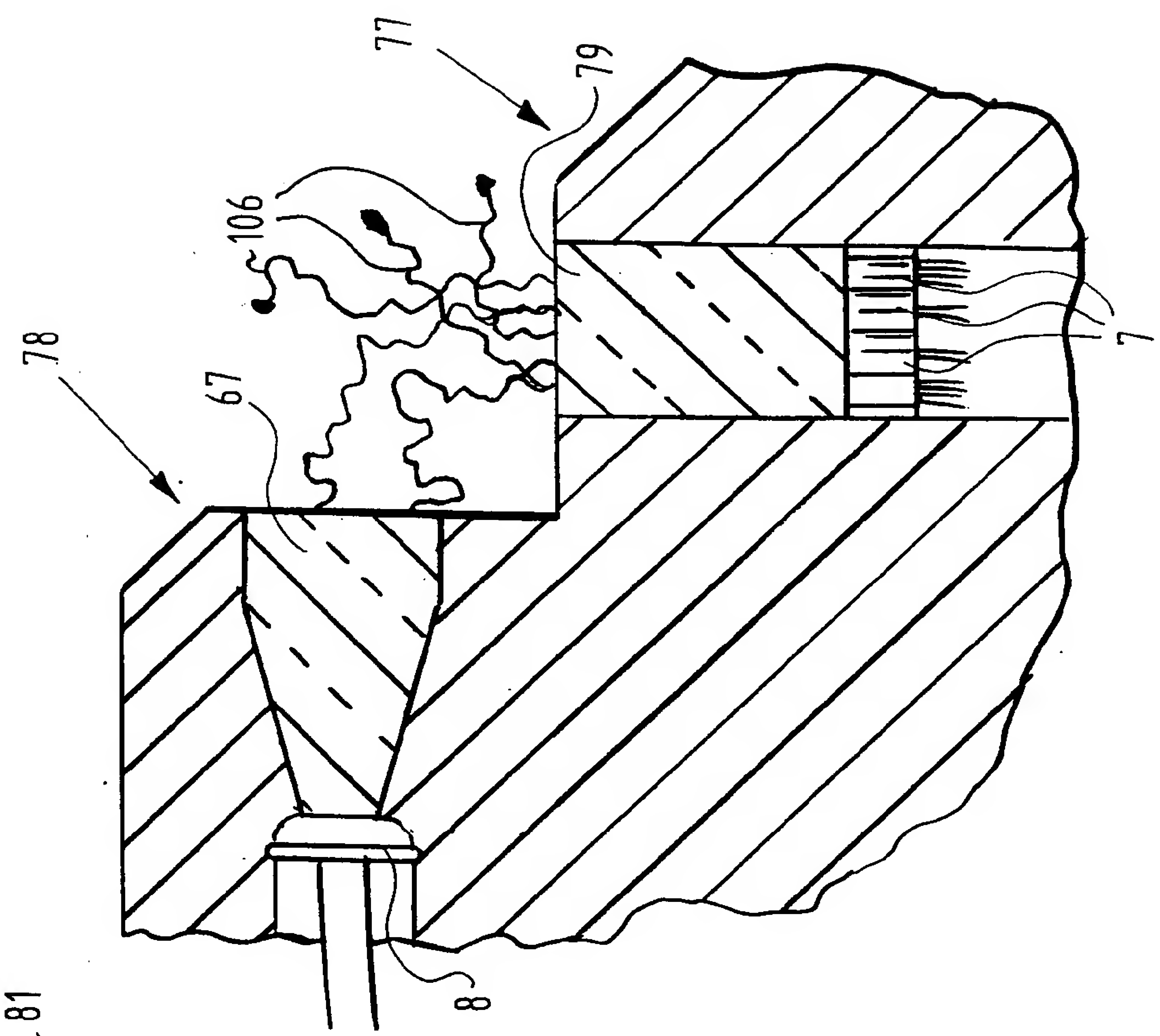


FIG. 19

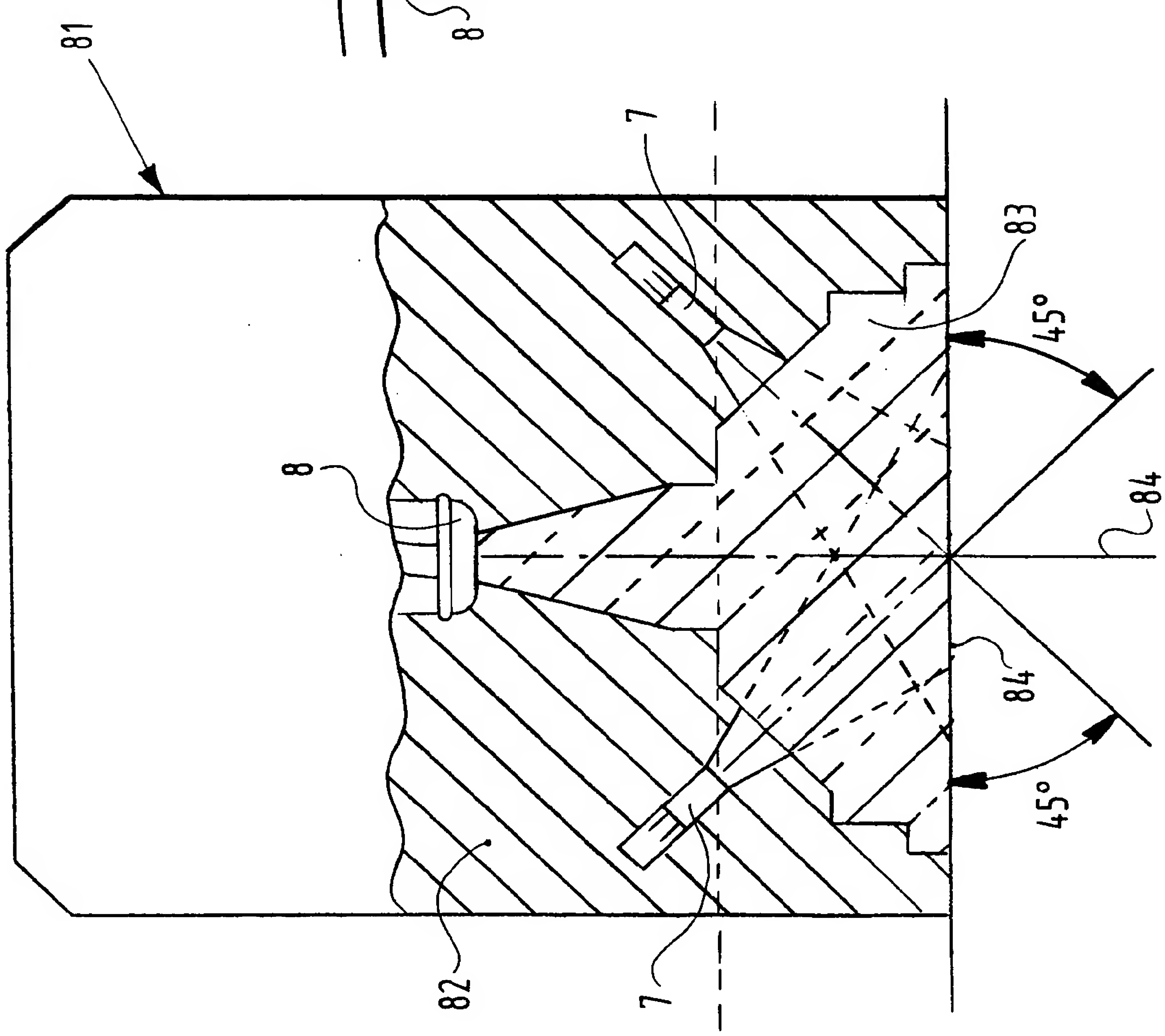


FIG. 18

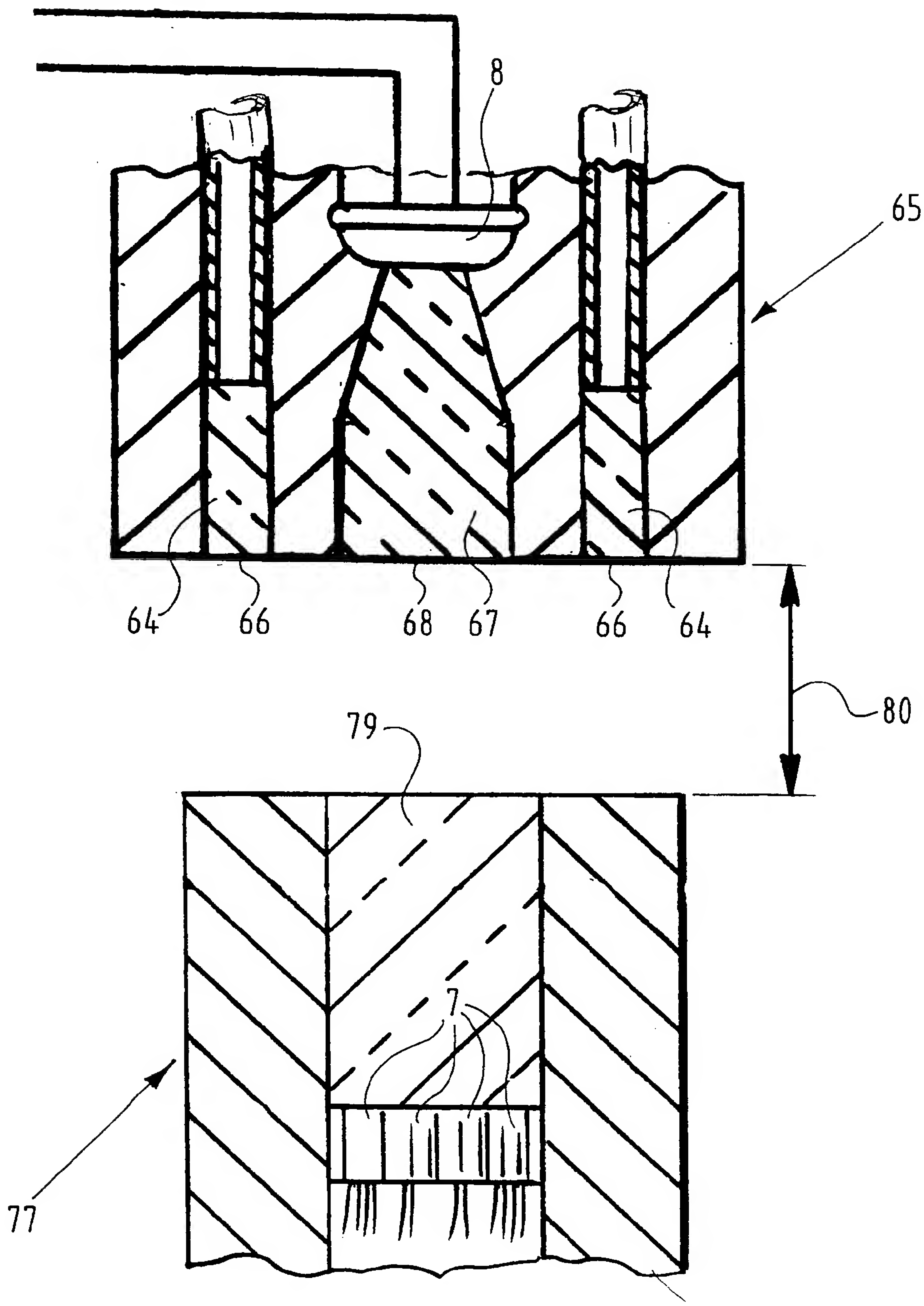


FIG. 20

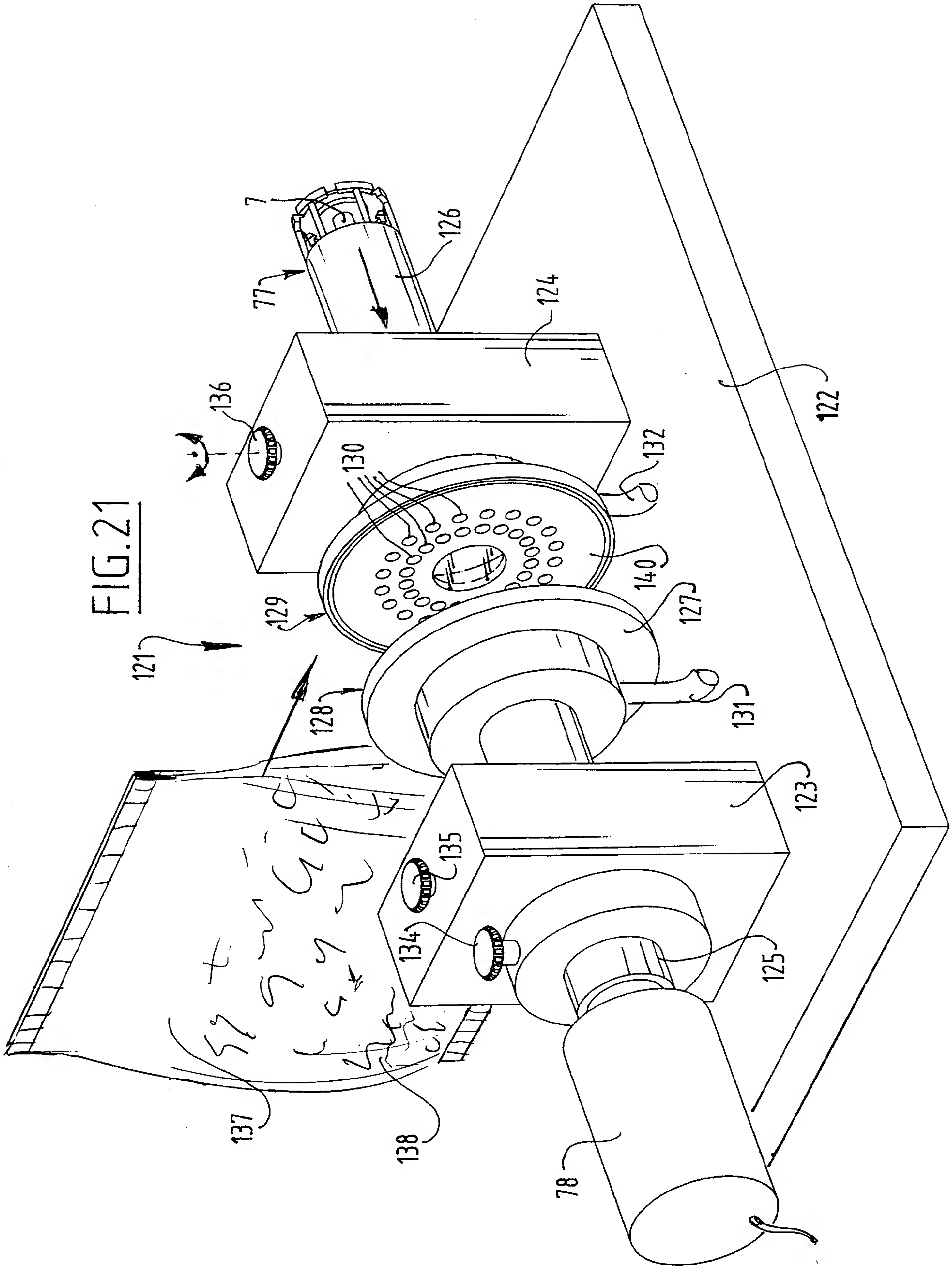

7
77
126
124
136
130
132
122
140
127
129
121
128
131
123
135
134
125
137
138
78

FIG.21

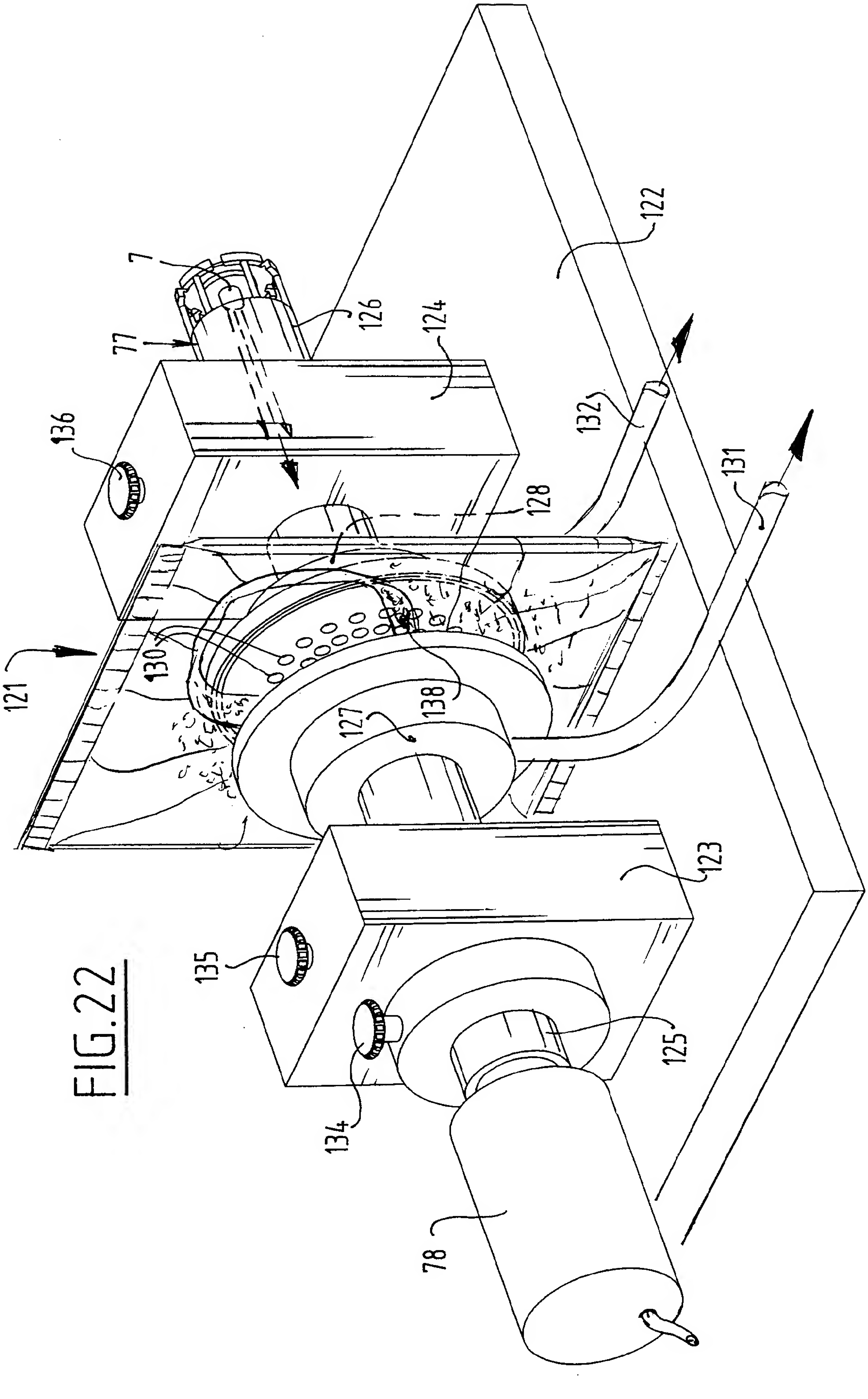

7
77
126
124
122
136
128
132
131
121
130
138
127
123
135
125
134
78

FIG.22

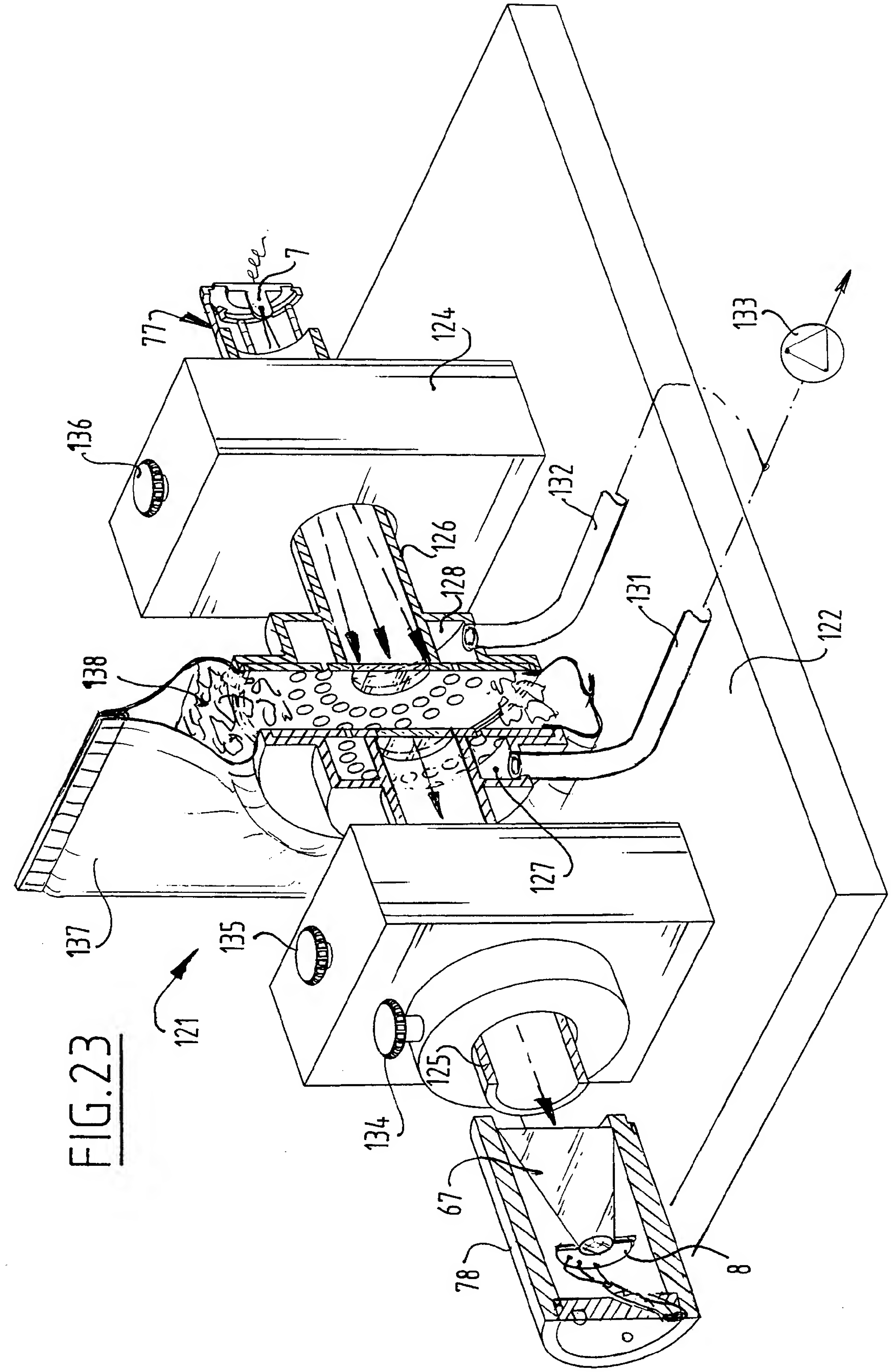

121
137
135
134
125
67
78
8
138
128
126
136
77
7
124
132
131
122
133
127

FIG.23

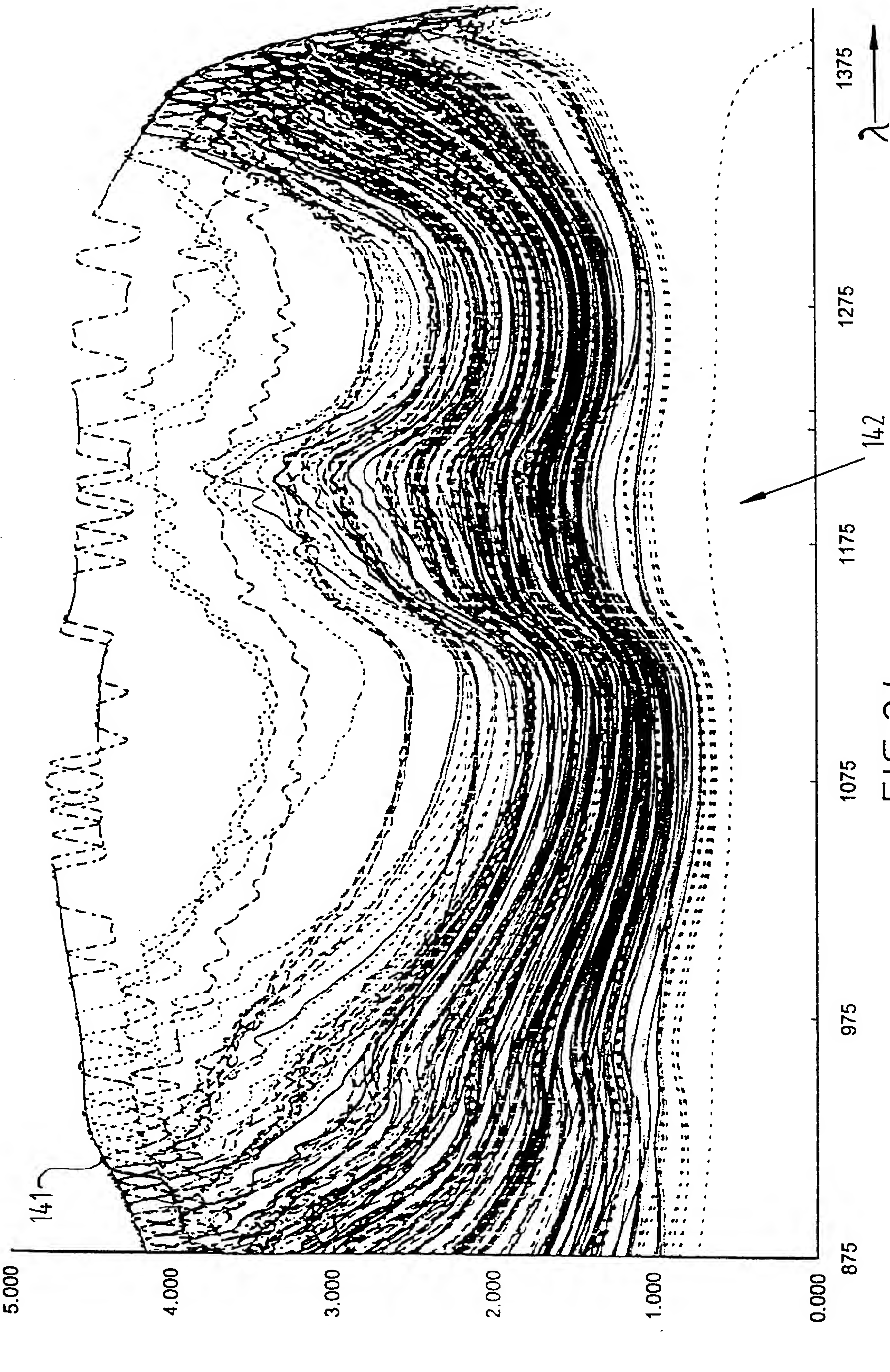

5.000
4.000
3.000
2.000
1.000
0.000
875
975
1075
1175
1275
1375
λ
141
142

FIG.24

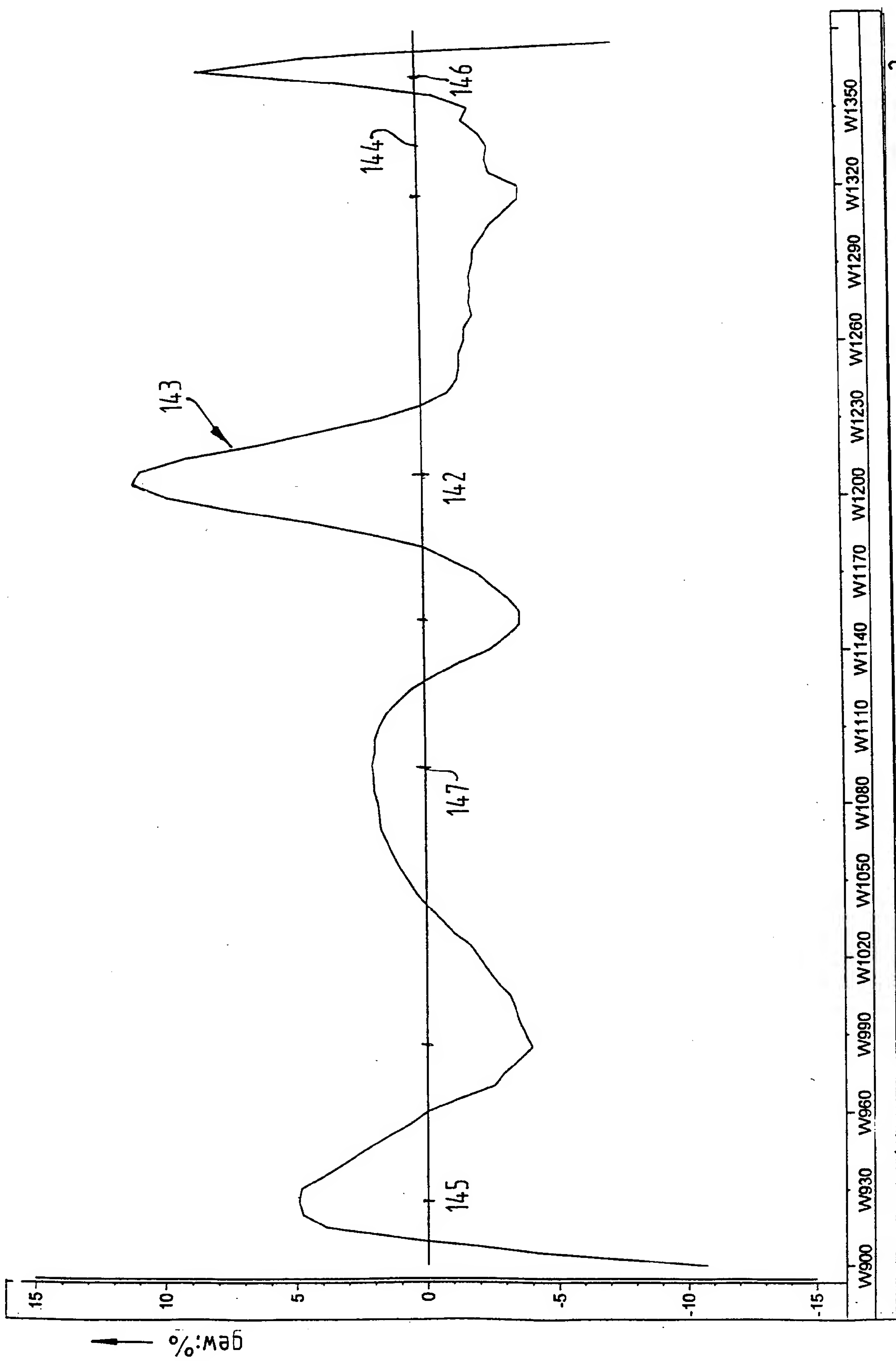

W900
W930
W960
W990
W1020
W1050
W1080
W1110
W1140
W1170
W1200
W1230
W1260
W1290
W1320
W1350
λ
15
10
5
0
-5
-10
-15
gew:%
143
144
146
142
147
145

FIG.25

INTERNATIONAL SEARCH REPORT

International Application No
PCT/NL 00/00273

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 A01J5/013 A01K29/00 G01N33/06 G01N21/85 G01J3/42 G01N21/53

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 A01J A01K G01N G01J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ, INSPEC, FSTA, COMPENDEX

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	GB 2 283 091 A (RICHMOND JOHN CHRISTOPHER) 26 April 1995 (1995-04-26) abstract page 1, line 1 - last line page 3, line 7 - line 13 page 4, line 4 - line 5 claim 2 figures 1,2 ---	1-3,5,8, 16,18, 20-22, 25,28,29

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
21 July 2000	28/07/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Verdoodt, E

1

Form PCT/ISA/210 (second sheet) (July 1992)

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 88 09920 A (FUTREX INC) 15 December 1988 (1988-12-15)	1-3,5,8, 16,18, 20-22, 25,28,29
A	page 1, line 8 - line 10 page 4, line 11 - line 20 page 4, line 24 - line 29 page 4, line 32 -page 5, line 2 page 5, line 25 -page 6, line 4 page 6, line 10 - line 15 page 7, line 31 -page 8, line 11 figures 1,2 ---	24,26
A	US 4 540 282 A (LANDA ISAAC J ET AL) 10 September 1985 (1985-09-10) abstract column 5, line 38 - line 52 column 10, line 36 - line 47 column 11, line 65 -column 12, line 3 figure 1 ---	4,16,27
A	US 4 775 794 A (BEHMANN HENRY) 4 October 1988 (1988-10-04) abstract column 3, line 16 - line 23 column 7, line 30 - line 40 figures 1-3 ---	6,12,16
A	EP 0 574 601 A (STARK EDWARD W) 22 December 1993 (1993-12-22) page 3, line 54 -page 4, line 12 figures 1A,2 ---	7
A	ROBERT PAUL ET AL: "MULTIVARIATE ANALYSIS APPLIED TO NEAR-INFRARED SPECTRA OF MILK" ANAL CHEM SEP 1 1987, vol. 59, no. 17, 1 September 1987 (1987-09-01), pages 2187-2191, XP000857119 abstract page 2188, paragraph 5 ---	9
A	US 4 532 892 A (KUZARA JAMES H) 6 August 1985 (1985-08-06) abstract column 10, line 25 -column 12, line 53; figures 1,8,9 ---	13-15,19
A	US 4 040 747 A (WEBSTER DONALD R) 9 August 1977 (1977-08-09) abstract column 10, line 7 - line 35 figure 1 --- -/--	34

1

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	US 4 884 891 A (BORSBOOM PETRUS C F) 5 December 1989 (1989-12-05) abstract column 5, line 45 - line 54 figures 3,4 ---	35
A	US 4 309 605 A (OKABE TADATOSHI) 5 January 1982 (1982-01-05) abstract column 3, line 38 - line 65 column 4, line 3 - line 25 column 5, line 33 - line 35 figures 3C,6 -----	17,23, 26,37-43

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/NL 00/00273

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
GB 2283091	A	26-04-1995	NONE			
WO 8809920	A	15-12-1988	EP	0316442	A	24-05-1989
			JP	63305234	A	13-12-1988
US 4540282	A	10-09-1985	NONE			
US 4775794	A	04-10-1988	NONE			
EP 0574601	A	22-12-1993	DE	69227025	D	22-10-1998
			DE	69227025	T	02-06-1999
US 4532892	A	06-08-1985	US	4463353	A	31-07-1984
US 4040747	A	09-08-1977	CA	998851	A	26-10-1976
			DE	2342686	A	07-03-1974
			GB	1432634	A	22-04-1976
			JP	938226	C	30-01-1979
			JP	49125082	A	29-11-1974
			JP	52035549	B	09-09-1977
			US	3861788	A	21-01-1975
			US	4037970	A	26-07-1977
US 4884891	A	05-12-1989	NL	8502138	A	16-02-1987
			DE	3682140	A	28-11-1991
			DK	354286	A	27-01-1987
			EP	0211465	A	25-02-1987
			ES	2000562	A	01-03-1988
			JP	63032352	A	12-02-1988
			NZ	216950	A	28-05-1990
US 4309605	A	05-01-1982	NONE			